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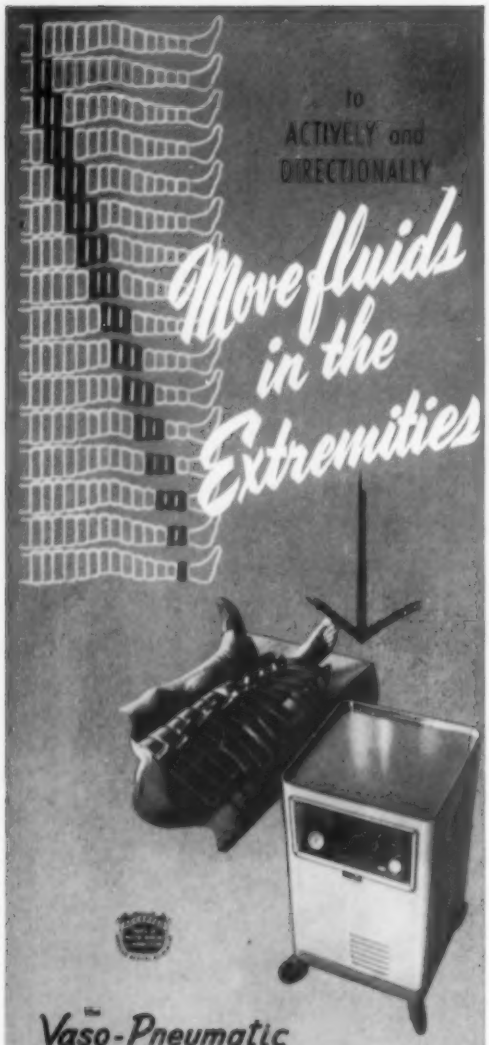

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Variations Between Measured and Biologically Effective Microwave Diathermy Dosage

Herman P. Schwan, Ph.D.
and
Kam Li, B.S., M.S.
Philadelphia

Introduction

One of the most important problems in diathermy is dosage determination for ultrashort wave or microwave power. It assumes added interest in view of recent reports concerning health hazards associated with powerful electromagnetic radiation.[1,2] Knowledge of all the parameters which influence the amount of absorbed energy is a necessity, if realistic proposals are to be made in reducing such hazards and if the biological effects of radiation are to be fully understood.

The extent to which all known effects of heat such as temperature rise, consequent vasodilatation and increase in metabolic rate, occur depends critically on the amount of applied energy. Unfortunately, no reliable method for objective dosage determination has been attained. It can be stated safely that difficulties in reproducing the same dosage are responsible for discrepancies in reports from different sources. To date, two rather crude technics have been used. One is objective. It relies on measurement of the power output of the generator. Its serious shortcoming is the complex relationship between generated power and biologically effective power. The second more subjective technic depends completely on the patient's statements with regard to heat sensation. The "mild sensation of heat" found most desirable corresponds to varying degrees of temperature rise in different individuals, depending on their temperament and psychological makeup. Moreover, stimulation of the sensory elements in the skin is a guide only where heat development occurs primarily on the surface of the body. With the advent of improved technics for deep tissue heating, temperature rise in skin, where the sensory elements are located, is through an extremely complicated relationship dependent on the effective temperature rise in deep tissue. In the extreme case, i.e., in possession of technics ideally suited for deep heating, skin temperature is no longer related to the biologically effective dosage. That is, it is the inefficiency of presently used deep heating technics which in part justifies relying on observation of skin temperature as a measure of depth dosage.

The impossibility of introducing significant technics for measuring the biologically effective dosage in the case of "ultrashort wave" diathermy is understandable. The high frequency currents, used in this technic, experience a tremendous reduction in strength per tissue volume due to spreading, which is most pronounced near the surface of the body. Moreover, the detailed technic, in which either inductive or capacitive electrodes are applied, has an enormous influence on the current spread. This fact is not generally recognized by physical therapists. Therefore, training in the details of electrode positioning is insufficient. This situation leads to an extremely variable procedure from the point of view of applied dosage and makes it impossible, without advanced training and corresponding research, for ultrashort wave diathermy to become a quantitative tool for purposes of deep heating.

The introduction of microwaves in diathermy, i.e., the utilization of electromagnetic waves for purposes of heating advances hope for improvement in this respect. Microwaves, as produced in currently used microtherm equipment,

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Department of Physical Medicine, School of Medicine, and Graduate School of Medicine, University of Pennsylvania.

Moore School of Electrical Engineering, University of Pennsylvania.

These studies were aided by a contract between the Office of Naval Research, Department of the Navy and the University of Pennsylvania (NR 119-358).

are propagated into the tissue in a relatively well-defined manner. Very definitely no spread in intensity, as observed with high frequency currents, exists. This means that it should be possible to establish a quantitative relationship between biologically effective dosage and generated power. In view of the better depth of penetration which microwaves achieve and the consequent increasing unreliability of subjective heat sensation as outlined, the establishment of this relationship is more desirable than in the case of ultrashort wave diathermy. Yet, very little work has been carried out to investigate this situation.[3,4] Usefulness of a mycalex plate between generator and patient for increased power consumption has been described. However, the effectiveness of this device is of questionable value whenever the patient is not completely free of subcutaneous tissue. A theoretical contribution has been made by Foelsche,[5] who gives for a few selected cases and for only one frequency (3000 Mc.) a discussion of the totally absorbed power to demonstrate its variability. Therefore, we decided to study this important item for the total range of involved parameters. This includes a) variation in amount of subcutaneous material; b) variation in frequency from 150 to 10,000 Mc.; c) variation in the properties of the important tissue, and d) variation in temperature.

We define "biologically effective dosage" as that part of the total energy which is not reflected from the body surface, i.e., that part of the power generated by the microwave equipment which is absorbed in the body and consequently is biologically significant. The relationship between biologically effective dosage and dosage produced by equipment is expressed in the form of a ratio of these two quantities and characterized by a "coefficient of energy absorption m."* This value is related to the "coefficient of reflection" r simply by the equation $r + m = 1$, where the coefficient r characterizes the relative amount of energy reflected from the body surface. Knowledge of the coefficient of energy absorption m is identical with the establishment of the biologically effective dosage: Simply multiply metered equipment output** by m and biologically effective dosage is obtained.

Of course, it is assumed in this relationship that no part of the radiation bypasses the body surface, i.e., that the radiator of the microwave equipment is sufficiently close to the body to avoid such bypass. This condition is fulfilled normally whenever the irradiated surface is larger than the radiator opening.***

Coefficients of Absorption

Coefficients of absorption have been determined under a number of different circumstances. The approach has been analytical and utilizes knowledge of the electrical properties of fatty and deep tissues at various frequencies. In turn, knowledge of the electrical parameters has been obtained from measurements described elsewhere.[7,8] While the dielectric properties of muscular material are very reproducible, we have found in more recent measurements, that the dielectric constant and conductivity of fatty material varies considerably from case to case. It is believed that this variation is due to relatively minor variation in water content as revealed by a particular frequency dependence of the conductivity of fatty tissue above 100 Mc., which is characteristic of the presence of bound water. The overall variation of both dielectric constant and conductivity amounts to about a factor of two. Dielectric constant and conductivity always vary in combination, i.e., a sample which shows rather high dielectric constant at the same time shows high conductivity. The ratio of dielectric constant and conductivity is much less variable from sample to sample than either quantity alone. Therefore, it has been decided to calcu-

*m should not be confused with the absorption coefficient α which is a part of the propagation constant characterizing the propagation of microwaves in a homogeneous material. Detailed discussion of this and the mechanism of absorption in tissue is listed in reference 6.

**Output energy of equipment can be measured easily with standard electronic technics.

***A more general statement would be that the dosage obtained by this rule gives the "available" biologically effective dosage. The true biologically effective dosage is smaller by a factor given by the ratio of beam cross section and body surface area hit by radiation.

late the coefficient of absorption values for two cases of dielectric parameters which are chosen in such a manner that the majority of all actual cases fall within the limitations set by the assumed values. The case of the higher dielectric constant and conductivity actually represents that of subcutaneous tissue with high water content; while the case of the lowest dielectric constant and conductivity corresponds to the type of dry fatty tissue found, for example, in pork. It is believed that in the human higher dielectric constant and conductivity values are found to be characteristic.

The coefficient of absorption has been calculated for various frequencies of interest (150, 400, 900, 3000, and 10,000 Mc.) and various thickness values of the subcutaneous tissue up to 3 cm. The results hold for body temperature (fig. 1 and 2). Figure 1 presents the results

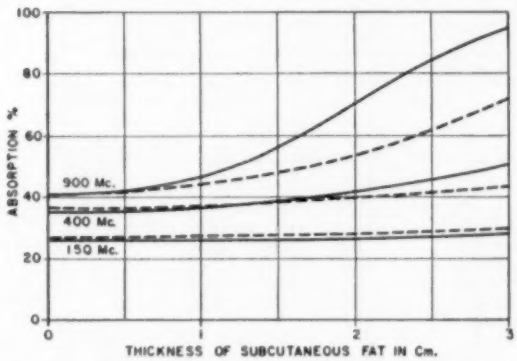

Fig. 1 — Percentage of absorbed (not reflected) microwave power for 150, 400 and 900 Mc. as function of thickness of subcutaneous material. The solid curves hold for subcutaneous (fat) tissue with relatively high, and the dashed curves for relatively low water content. Actual conditions lie in most cases between, but somewhat nearer to the solid curves.

for frequencies of 150, 400, and 900 Mc., while figure 2 gives the results for the higher frequencies 3000 and 10,000 Mc. The solid curves represent the results obtained from high dielectric constant and conductivity values, i.e., assumes fatty subcutaneous material with relatively high water content as previously discussed, while the dashed curves are more characteristic for relatively dry subcutaneous material. The dielectric tissue data used for these and all the following discussions are summarized in table 1.

In order to determine the influence of temperature on the results, the cases illustrated by the solid curves in figures 1 and 2 have been recalculated for conductivity values which are half and twice as high as those assumed in figures 1 and 2. The dielectric constant of fatty material is relatively temperature independent, as shown in a previous study,[7] while its conductivity has a temperature coefficient of more than 4 per cent per centigrade. Change of the conductivity by a factor of two corresponds, therefore, to a temperature change of about 15 C. These rather large temperature changes of 15 C. above and below body temperature do not occur in actual practice. They have been chosen for our work in order to obtain pronounced variation in the re-

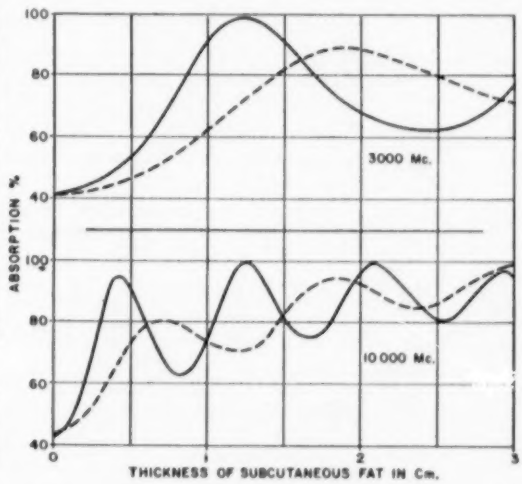

Fig. 2 — Percentage of absorbed microwave power for 3000 and 10,000 Mc. Variation in results with water content of fatty material (high amount presented by solid curves, low amount by dashed curves) is excessive.

sults. They will be used in pointing out the relative unimportance of temperature in both fatty and deep tissue on the amount of absorbed energy. The results are summarized in figure 3 for the frequencies of 150, 400 and 900 Mc., and in figure 4, for the frequencies of 3000 and 10,000 Mc. in the form of continuous curves. The block areas in fig-

ure 3 characterize the optimal possible fluctuation in the percentage of absorbed energy as the thickness of the subcutaneous material is permitted to vary from 0 to one-half inch throughout the range of practical importance in actual practice. For each frequency, three ranges of variations are given—the left one corresponding to high conductivity values of the subcutaneous material (temperature about 50 C.); the middle one to normal conductivity (body temperature), and the right one to low conductivity (temperature about 20 C.).

eous tissue for frequencies up to 400 Mc., as long as the subcutaneous tissue is not thicker than 3 cm.; and up to 900 Mc. when the subcutaneous tissue is less than one-half inch thick. Furthermore, the amount of absorbed energy is independent from the temperature in the subcutaneous material for frequencies below 900 Mc. (fig. 3). Variation in the temperature of the deep tissue has a very small influence, since the reflection of energy at the boundary between deep and subcutaneous tissue is practically temperature independent, as a consequence of the vastly different di-

Table 1: Dielectric constant E and conductivity K ($Ohm^{-1}cm^{-1}$) of subcutaneous fatty tissue, as used in the discussions.

Frequency	I		II		III			
	E	K	E	K	E	K	E	K
150 Mc.	7.6	6.6×10^{-4}	3.8	3.3×10^{-4}	7.6	3.3×10^{-4}	7.6	6.6×10^{-4}
400	6.8	7.8	3.4	3.9	6.8	3.9	6.8	7.8
900	6.1	9.1	3.05	4.5	6.1	4.5	6.1	9.1
3,000	4.4	11.8	2.2	5.9	4.4	5.9	4.4	11.8
10,000	3.3	26.3	1.65	13.1	3.3	13.1	3.3	26.3
	Figs. 1 and 2 solid curves		Figs. 1 and 2 dashed curves					
							Figs. 3 and 4	

Frequency	III	
	E	K
150 Mc.	7.6	13.2×10^{-4}
400	6.8	15.6
900	6.1	18.1
3,000	4.4	23.5
10,000	3.3	52.6

The dielectric data in column I are characteristic for fatty tissue with relatively high water content and the data in the second column characteristic for "dry" fatty material. The data in column III are characteristic for fatty material with relatively high water content at temperature of about 20 C., body temperature 37 C. and about 50 C.

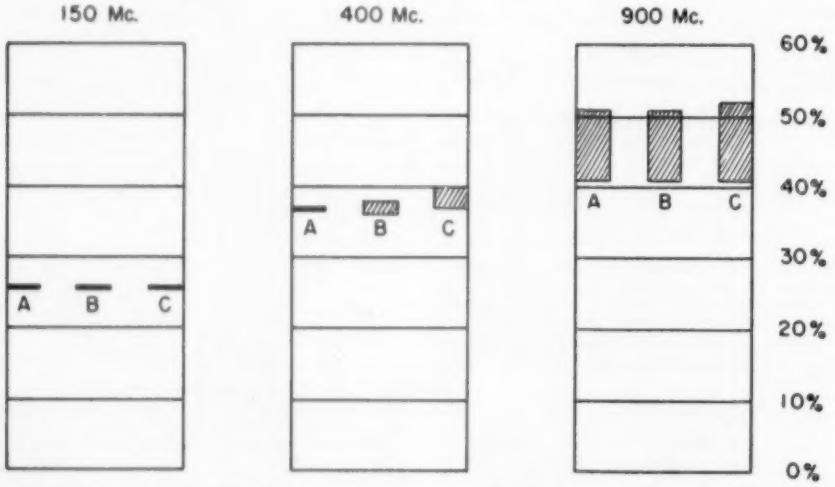

Fig. 3 — Optimal ranges of variation of percentage of absorbed microwave power with thickness of subcutaneous tissue up to values of one-half inch at 150, 400 and 900 Mc. frequencies. The results are presented for different conductivity of subcutaneous material, corresponding different temperatures. Results hold for (A) 50 C., (B) for body temperature, and (C) for 20 C. Only little dependence on temperature is noticeable.

Discussion

Figures 1 and 3 show that the amount of absorbed energy is practically independent from the amount of subcutaneous tissue for frequencies up to 400 Mc., as long as the subcutaneous tissue is not thicker than 3 cm.; and up to 900 Mc. when the subcutaneous tissue is less than one-half inch thick. Furthermore, the amount of absorbed energy is independent from the temperature in the subcutaneous material for frequencies below 900 Mc. (fig. 3). Variation in the temperature of the deep tissue has a very small influence, since the reflection of energy at the boundary between deep and subcutaneous tissue is practically temperature independent, as a consequence of the vastly different dielectric properties of deep tissue and subcutaneous fat. The variation of the absorbed energy with the dielectric properties of the subcutaneous material,

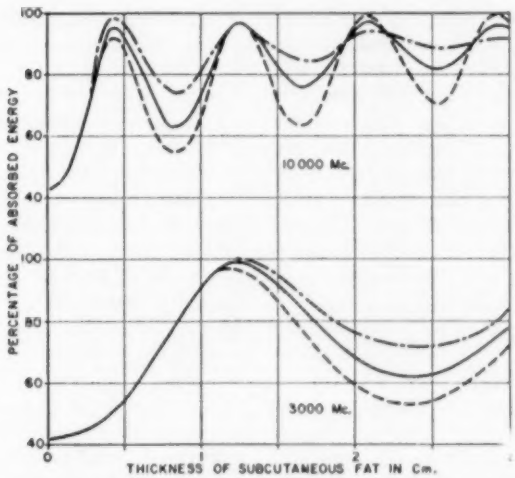

Fig. 4 — Variation of percentage of absorbed power for 3000 and 10,000 Mc. at body temperature (solid curves), at 20 C. (dashed curves) and at 50 C. (point-dashed curves) as function of thickness of subcutaneous material.

as caused by variation in bound water in the fatty material, is small at 150 and 400 Mc. for all possible thickness values of subcutaneous fat up to 3 cm., and small up to 900 Mc. when the fatty layer is thinner than one-half inch (solid and dashed curves in fig. 1). Finally, the variation with frequency is relatively small, but only when the fat layer can be neglected. Figure 1 indicates a maximum variation from 35 to 46 per cent as the frequency varies between 400 and 900 Mc., as long as the fatty layer is thinner than 1 cm., but varies between 35 and 95 per cent when the fatty layer may be as thick as 3 cm. In summary, a remarkably constant amount of energy is absorbed for low frequencies below 400 or 900 Mc. as important parameters such as temperature, water content of fatty tissue, and thickness of fat layer are varied.

The picture changes rapidly when the frequency increases, especially for larger thickness values of the subcutaneous material. Variations in the amount of subcutaneous material already cause, at 900 Mc., appreciable changes in the absorption value for thickness values larger than 1.5 cm. At 3000 Mc., the absorption value varies through maximum and minimum as the thickness varies and at 10,000 Mc., a rather critical relationship between thickness and amount of absorbed energy exists. Curves in figures 1, 2 and 4 show that the amount of absorbed energy fluctuates between 40 and 100 per cent, or by a factor of 2.5. This variation is more pronounced for the case of fatty material with dielectric parameters characteristic for relatively high water content. The amount of water in the subcutaneous material has a strong effect on the coefficient of absorption at 3000 and 10,000 Mc., as can be seen from a comparison of the solid and dashed curves in figure 2. At 900 Mc., a noticeable dependence is obvious only when the amount of subcutaneous material is thicker than about 1.5 cm. (fig. 1). The curves in figure 4, on the other hand, demonstrate that temperature variation has no strong effect on the absorption as long as the deviation from body temperature is smaller than 5 or 10 degrees centigrade, which is always evident in clinical practice. In summary, it can be stated that only for frequencies which are substantially lower than presently used microwave frequencies, a reproducible relationship between available and biologically effective dosage exists.

On the basis of results listed in figures 1-4, it is possible to discuss the performance of the mycalex "lambda quarter" transformer as suggested by Gersten et al[3] and Martin et al,[4] for increasing the amount of absorbed energy. The electrical properties of mycalex are quite similar to those of fatty material with relatively high water content. The use of a mycalex plate of proper thickness in front of the body corresponds to a fatty layer of such thickness that it changes a minimal value to one of optimal absorption. This thickness is about 1 cm. for 3000 Mc. (fig. 2) and increases absorption percentage without this layer from 40 to nearly 100 per cent.* In other words, the mycalex transformer increases the amount of absorbed energy by about a factor of 2.5 in excellent agreement with the experimental published record when no subcutaneous fat exists. However, if the patient, again treated with about 3000 Mc., possesses a natural layer of about 1 cm. fatty tissue, he possesses so to say, his natural mycalex transformer and by adding artificially another mycalex stub, a case is created which corresponds to a fatty layer of 2 cm., even though the patient possesses a fatty layer only 1 cm. in thickness. The result is an absorption reduction from 95 to 60 per cent. Use of the mycalex transformer has actually reduced the efficiency of energy transfer by a factor of about 1.5. This discussion can be extended to clarify one very important fact. The use of the previously proposed matching device is of questionable value in view of the fact that its beneficial effect in some cases is offset by its energy reducing property in other cases. Relatively minor variations in the amount of subcutaneous material cause tremendous fluctuations in the efficiency of the "impedance transformer."

Its use, therefore, can be recommended only when absolute familiarity with the outlined facts exists, so that the influence of subcutaneous tissue can be properly taken into consideration.

The discussions so far do not take into account the effect of skin on the amount of absorbed energy. Actually, for frequencies substantially lower than 3000 Mc., the skin is practically transparent for the electromagnetic radiation, since its thickness is small compared with the wavelength of radiation in skin and the losses of the skin are sufficiently low to be neglected.* However, at frequencies above 3000 Mc., this is no longer correct and much more difficult relationships result. This only contributes to the pronounced dependence of the amount of absorbed energy from the amount of subcutaneous material and emphasizes our conclusion that radiation diathermy should operate at substantially lower frequencies than 3000 Mc., in order to provide reproducible ratio of generated and biologically effective dosage.

Conclusions

It has been shown that for frequencies in excess of 1000 Mc., the amount of microwave radiant energy absorbed which becomes biologically effective, depends increasingly on the amount of subcutaneous tissue. Fluctuations of the amount of absorbed energy by nearly a factor of 3 are observed when only small fluctuations of the amount of subcutaneous material occur. A reproducible relationship between generated and absorbed power can be obtained only at frequencies lower than about 1000 Mc. At such low frequencies a relationship between generated and biologically effective dosage exists, which is practically independent from the amount of subcutaneous tissue, temperature, condition of fatty tissue, etc. By the same token,

*Actually, presently used frequency is 2450 Mc., but the difference against 3000 Mc. is insignificant for this discussion.

*Electrical "transparency" exists when the electrical wavelength in skin is more than four times larger than the thickness of the skin. For 2500 Mc., i.e., a wavelength of 12 cm. in air, the wavelength in skin will be about 2 cm., since the dielectric constant of skin Es is near 40 and the wavelength in skin by the factor $\sqrt{Es}$ smaller than the wavelength in air. The wavelength in skin is, therefore, about 6 times larger than the thickness of skin itself and not much more than the critical value of 4 where skin exhibits a major influence on the absorption of energy. A discussion of the effects of skin has been given for 10 cm. wavelength by Foelsche,[5] who has shown that skin in front of the subcutaneous tissue may strongly affect the amount of absorbed energy.

Table 2: The advantages and disadvantages of various forms of microwaves for diathermy application are summarized. Frequencies of 900 Mc. and somewhat below are found to provide a best compromise.

	400 Mc.	900 Mc.	2500 Mc.
Focusing	poor	medium	good
Depth of penetration in muscular tissue	high	medium	poor
Amount of heat development in subcutaneous fat	very low	low	medium to high
Relationship between measured and effective dosage	very well defined	well defined	very unpredictable

it can be stated only for frequencies below 1000 Mc., that bone structures have negligible influence in the propagation of microwaves as long as the diameter of these structures is smaller than about 3 cm. We conclude, therefore, that the use of frequencies below 1000 Mc. enables the practical physician to predict from metered instrument output, the biologically effective dosage. Therefore, microwave diathermy should operate below 1000 Mc. We have shown previously that microwave diathermy should operate below 1000 Mc. for two reasons namely, lower frequencies provide better depth of penetration into the deep tissues where vasodilatation and increase in metabolic rate are desired[9] and, lower frequencies reduce effectively the selective heating of subcutaneous tissue which at presently used 2500 Mc. varies greatly with the amount of such tissue.[6,10] It is very fortuitous that the present investigation of another point of extreme importance, namely the establishment of procedures for better definition of dosage, again calls for the choice of lower frequencies than presently used. In view of the desirability of combining the advantages of low frequency with the possibility of good directional properties of high frequencies, a compromise between 600 and 900 Mc. is believed to be most desirable. The respective merits of 400, 900 and 2500 Mc. may be summarized as shown in table 2.

Summary

The amount of absorbed microwave power has been investigated and is found to depend on the amount of subcutaneous tissue when the frequency exceeds 1000 Mc. On the other hand, the relationship between measured and biologically effective power is surprisingly independent of temperature, amount of subcutaneous tissue and electrical properties when the frequency is substantially lower than 1000 Mc. In the interest of a dependable relationship between instrument indicated power and biologically effective power, microwave diathermy operating below 1000 Mc. is, therefore, strongly recommended. This statement supports earlier results based on different arguments. The efficiency of matching devices recommended for increase of absorbed power is analyzed and found to depend critically on the amount of subcutaneous material. Minor fluctuations of subcutaneous material can reverse the beneficial effects of such devices into the opposite.

For reprints, write Dr. Schwan, School of Medicine, University of Pennsylvania, Philadelphia 4, Pa.

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The Influence of Electrical Stimulation on the Work Output and Endurance of Denervated Muscle

Khalil G. Wakim, M.D.,
Section of Physiology,
and
Frank H. Krusen, M.D.,
Section of Physical Medicine and Rehabilitation,
(With the technical assistance of Robert Arns)
Mayo Clinic and Mayo Foundation,*
Rochester, Minn.

A general survey of the literature indicates that a few investigators did not obtain beneficial effects from electrical stimulation of denervated muscle,[1-4] while many presented evidence of benefit.[5-13] Moreover, in many clinics and hospitals where patients with paralyzed muscles are under care, electrical stimulation is used therapeutically. However, there is no unanimity of opinion as to the number of stimuli to be applied per unit of time, or as to the duration of periods of electrical stimulation. There is no indication whether the electrical stimulation should be given more than once per day or per week.

Eccles[14] found that daily periods of stimulation ranging from 10 seconds to 2 hours were equally effective in preventing total atrophy of disuse. Wehrmacher, Thomson and Hines,[15] who used treatment varying from 3 to 180 seconds, noted that its effectiveness was independent of its duration. Osborne and associates[9] reported that electrical stimulation for 10 minutes daily, 6 days a week, greatly retarded and even prevented, atrophy of paralyzed muscles.

In a previous report[10] one of us, with the assistance of Mr. Arns, presented evidence based on measurements of the blood supply to muscles, which indicated that the optimal frequency for stimulation was in the neighborhood of 16 impulses per second. This frequency most greatly increased the blood flow to the muscles, whether stimulation was applied directly to the nerve which supplied the muscle or percutaneously. It has been found, also, that daily electrical stimulation of denervated muscle partially checks progress of the atrophy which usually follows denervation.[17]

This study was undertaken to answer two and possibly three questions, namely: 1. Does electrical stimulation increase the work output and endurance of denervated muscle? 2. Do repeated daily periods of electrical stimulation, of varying duration, influence proportionately, inversely, or not at all, the endurance and work output of denervated muscle as well as the course of atrophy of denervation? If the answer to the second question were positive, answer to a third question — Is it likely that an optimal duration and number of daily

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treatments by electrical stimulation can be found? — would be sought.

Methods

Adult albino rats of an average body weight of about 250 gm. were used in this study. Male animals of the same weight, and litter mates whenever possible, were divided initially into nine groups of equal number. With the animals under ether anesthesia, one hind leg of each rat (groups I to VIII inclusive) was denervated by excision of a segment of each of two nerves, namely the sciatic nerve at the level of the greater trochanter of the femur and the femoral nerve at the base of the femoral triangle. After denervation, the animals in group I were kept unstimulated for use as denervated controls. Henceforward, an animal of which one hind leg was denervated will be called a "denervated animal." The rest of the groups of denervated animals were stimulated by means of an electronic stimulator which delivers a square wave type of current of a duration of 1 millisecond, at a frequency of 16 impulses per second. The duration of each period of stimulation was different for each group of denervated animals. Animals of group I were not stimulated at all. Animals of group II were stimulated for 30 minutes once daily; those of group III were stimulated for 30 minutes in the morning and for 30 minutes in the afternoon; those of group IV were stimulated 5 minutes every half hour for 8 hours, starting at 8 a.m. and continuing until 5 p.m., with 1 hour of rest at noon; those of group V were stimulated 10 minutes every half hour for 8 hours distributed as described; those of group VI were stimulated 15 minutes every half hour for the 8 hours and those of group VII were stimulated 20 minutes every half hour for the 8 hours. Animals of group VIII were stimulated throughout the described 8-hour day. Animals of group IX were normal controls which were neither denervated nor stimulated.

The electrodes were applied daily to the thigh, with electrode jelly under them, and were fastened to the shaved skin with collodion. The current was that which would cause maximal contraction of the whole extremity. The rats were housed in individual cages during stimulation (fig. 1). This procedure of stimulation was repeated on each of the denervated, stimulated rats every day for 25 to 30 days, at the end of which the denervated gastrocnemius muscle group was tested for work output and endurance. For the testing, electrical stimulation again was used. To write of this as "test-stimulation," will prevent confusion with the preliminary period of 25 to 30 days of therapeutic electrical stimulation.

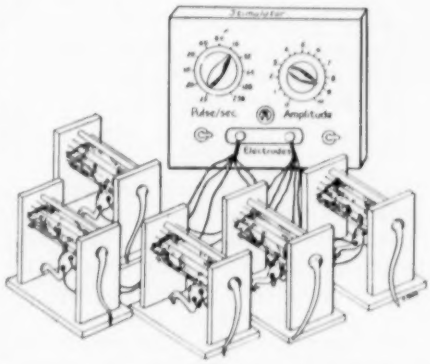

Fig. 1 — Housing of the animals in individual cages during stimulation of the denervated extremity. Note the position of the electrodes on the extremity and their connection with the stimulator.

The operation preliminary to the testing and the testing itself were performed with the animals under anesthesia produced by pentobarbital sodium. The Achilles tendon was excised from its insertion. From the freely hanging tendon, a 100-gm. weight was suspended by a wire which, midway of its length, passed around a tallying pulley (fig. 2). The muscles were test-stimulated by a current introduced once every 3 seconds for several hours, during which time work output was recorded every 100 seconds by use of the timer illustrated in figure 2. Every tally unit represents a 4-cm. lift of the weight. Therefore, every unit registered represents 400 gm.-cm. of work done by the activated muscle group. About 200 observations were ob-

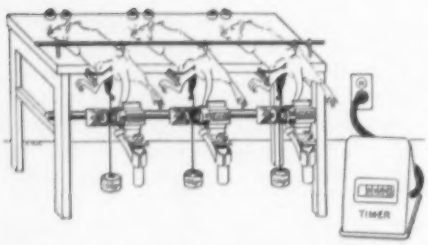

Fig. 2 — Position of the rats with the Achilles tendon isolated and connected to the weight. The wire from which the weight is suspended passes around a pulley for measurement of work output of the muscles.

tained on work output from each animal. After that the animals were killed and the gastrocnemius, the anterior tibial and the plantaris muscles of the denervated extremity were carefully isolated, weighed and compared with those of the intact contralateral limb.

Results

Comparison of the data in tables 1 and 2 on the work output of denervated unstimulated, denervated stimulated, and intact muscles indicates that therapeutic electrical stimulation enabled denervated muscles to do more work than the corresponding denervated unstimulated muscles of litter mates. For example, it is shown in table 1 that the total work output of denervated unstimulated muscle averaged only 19.9 ± 3.9 gm.-meters per 100 seconds while the average work output of denervated stimulated muscles ranged from 41.2 ± 5.8 to 135.9 ± 15 gm.-meters per 100 seconds. The average total work output of denervated unstimulated muscle was only 7.6 per cent of that of intact muscle as compared with the average total work output of denervated stimulated muscle, which averaged from 15.7 to 51.8 per cent of that of intact muscle. Electrical stimulation, even for very short periods, was helpful. The total work output of denervated muscle, stimulated for only 5 minutes each half hour (group IV of table 1) averaged 40 per cent of normal. The highest average total work output of denervated muscle, as shown in table 1, was 135.9 ± 15 gm.-meters per 100 seconds, while that of the intact muscle was 262.4 ± 9.2 gm.-meters. This suggests that electrical stimulation neither completely prevents the reduction of, nor completely replenishes, the power of denervated muscle to do work such as it should do when its connections with the nervous system are intact.

Table 2 demonstrates that the work output in the second and third 100 seconds was much less if the muscle was denervated and unstimulated than if it was denervated and stimulated or intact. These values for initial work output (table 2) and the average values for total work output (table 1) per 100 seconds indicate that denervated unstimulated muscle could not put out as much work as denervated stimulated muscle, and that its endurance was limited as well.

The influence of varying the duration of the periods of daily electrical stimulation of denervated muscle is demonstrated in figures 3 and 4. Whether the denervated muscle was stimulated continuously throughout the 8-hour day or for only 5 minutes every half hour throughout the 8-hour day, the degree of improvement of the muscle in endurance and in ability to do work did not differ greatly (fig. 3).

Figure 4 represents the average work output for the first 100 seconds. The values are higher than the average values for the total series of observations represented in figure 3. In the first 100 seconds (fig. 4), there was less difference between the work output of muscles which were stimulated 5 minutes each half hour and those which were stimulated continuously throughout the 8 hours than was found when the same comparison was made (fig. 3) relative to the average total work output. Similarly, the average work output of denervated unstimulated muscles for the first 100 seconds (fig. 4) is higher than the corresponding average representing the total output (fig. 3). This indicates, again, the inferiority in endurance of the denervated unstimulated muscle as compared with that of denervated stimulated muscle.

Table 1: Total Work Output of Denervated Unstimulated, Denervated Stimulated, and Intact Muscle

Group	State of muscle	Daily stimulation (minutes)	Number of animals	Number of 100-second observations	Average of total work output	
					Gram-meter per 100 sec.*	Per cent of normal
I	Denervated	None	12	2174	19.9 ± 3.9	7.6
II	"	30	14	2434	41.2 ± 5.8	15.7
III	"	60	17	3319	69.8 ± 10.1	26.6
IV	"	80	13	2463	105.0 ± 13.5	40.0
V	"	160	16	2878	115.6 ± 9.9	44.1
VI	"	240	11	1979	113.7 ± 15.5	43.3
VII	"	320	12	2225	116.0 ± 16.2	44.2
VIII	"	480	12	2276	135.9 ± 15.0	51.8
IX	Intact	None	12	2274	262.4 ± 9.2	100

*The value following the ± is the standard error of the mean.

Table 2: Initial Work Output of Denervated Unstimulated, Denervated Stimulated, and Intact Muscle

Group	State of muscle	Daily stimulation (minutes)	Number of animals	Average work output, gram-meters/100 seconds*		
				1st 100 seconds	2nd 100 seconds	3rd 100 seconds
I	Denervated	None	12	63.3 ± 10.0	20.0 ± 2.7	17.7 ± 2.4
II	"	30	14	91.7 ± 8.0	49.7 ± 8.5	47.4 ± 5.7
III	"	60	17	115.3 ± 13.1	67.3 ± 9.5	72.7 ± 11.7
IV	"	80	13	134.8 ± 11.4	83.1 ± 9.4	99.4 ± 12.8
V	"	160	16	139.5 ± 11.4	83.0 ± 12.9	95.5 ± 14.0
VI	"	240	11	136.7 ± 18.5	91.6 ± 16.4	96.5 ± 14.1
VII	"	320	12	142.0 ± 18.9	86.7 ± 15.2	104.7 ± 16.9
VIII	"	480	12	145.7 ± 11.8	99.7 ± 8.4	118.7 ± 13.1
IX	Intact	None	12	296.3 ± 9.2	232.3 ± 11.2	241.7 ± 9.9

*The value following the ± is the standard error of the mean.

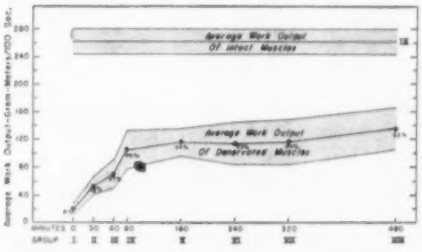
Average Work Output
Of Intact Muscles
Average Work Output
Of Denervated Muscles
MINUTES 0 30 60 80 160 240 320 480
GROUP I II III IV V VI VII VIII

Fig. 3 — Influence of therapeutic stimulation on total work output of denervated muscle. The shaded areas represent two standard deviations from the average values. The numbers on the various points of the curve for denervated muscles give the work output in percentage of that for intact muscles. From group IV to group VIII inclusive, stimulation was respectively for 5, 10, 15, 20 and 30 minutes of each half hour through the 8-hour day. Thus, the number of minutes below the graph represent, in group IV, 5 x 16=80; in group V, 10 x 16=160, and so on until, in group VIII, the multiplication is 30 x 16, or 480. This quantity represents all the minutes of an 8-hour day and in group VIII actually, stimulation was continuous throughout 8 hours. The percentage difference between groups IV and VIII was slight.

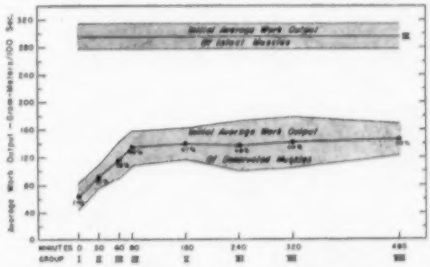
Initial Average Work Output
Of Intact Muscles
Initial Average Work Output
Of Denervated Muscles
MINUTES 0 30 60 80 160 240 320 480
GROUP I II III IV V VI VII VIII

Fig. 4 — Influence of therapeutic stimulation on the initial (first 100 seconds) work output of denervated muscle. The explanation of the characters and shading used on the graph is the same as that given in the legend of figure 3. Except that the average total work output represented in figure 4 is slightly higher than that represented in figure 3, the graphs are much the same.

It is evident (table 3) that a muscle loses about 75 per cent of its weight in 25 to 30 days after denervation. Treatment by electrical stimulation reduces,

but does not prevent, loss of weight after denervation. Even continuous stimulation for the described 8 hours daily does not prevent such loss of weight. Loss of weight runs roughly parallel with reduction in work output and in endurance.

and endurance of denervated stimulated muscle can be attributed to retardation in loss of the following: Weight, myosin, adenosine triphosphatase, and adenosine triphosphate.

In this study, however, no matter how often a denervated muscle was stimulated, its work output and endurance were far below those of intact normal muscle. Hence, after denervation, therapeutic electrical stimulation would be expected to be helpful but it should not be expected to render the muscle capable of retaining or re-establishing its normal state.

Table 3: The Weight of Intact Muscles, and the Weight of Unstimulated and Stimulated Muscles 25 to 30 Days After Denervation

Group	State of muscle	Daily stimulation (minutes)	Weight of muscle, mg. Gastrocnemius Weight	% of normal	Plantaris Weight	% of normal	Tibialis anterior Weight	% of normal
I	Denervated	None	456	24	102	26	149	24
II	"	30	486	26	106	27	152	25
III	"	60	641	34	129	32	139	23
IV	"	80	701	37	133	33	177	29
V	"	160	611	32	102	26	159	26
VI	"	240	740	39	134	34	184	30
VII	"	320	574	30	118	30	143	23
VIII	"	480	645	34	131	33	175	29
IX	Intact	None	1887	100	398	100	613	100

Comment

In a previous study[17] it was noted that the reddish color imparted to muscle by myohemoglobin is much reduced in denervated unstimulated muscle as compared with denervated stimulated muscle. This is in accord with the known fact that the uptake of oxygen[18] by denervated muscle is reduced. Also, denervation results in metabolic alterations dependent on change in the quantity of glycogen, myosin, creatine phosphate, adenosine triphosphate, and in the activity of adenosine triphosphatase, succinic dehydrogenase and cytochrome oxidase.[19-25] By these changes, the ability of denervated muscle to produce energy is reduced far below that of normal muscle.

Stimulated denervated muscle, however, is less handicapped than is unstimulated denervated muscle because electrical stimulation partially restricts the reduction in enzymic action and chemical content. Myosin is considered to be the substrate of the contractile mechanism. Adenosine triphosphate in the presence of its enyzme, adenosine triphosphatase, initiates muscular contraction. As compared with denervated unstimulated muscle, the greater work output

Summary

This study was undertaken to answer two and possibly three questions: 1. Does electrical stimulation increase the work output and endurance of denervated muscle? 2. Do repeated daily periods of electrical stimulation, of varying duration, influence proportionately, or inversely, or not at all, the work output and endurance of denervated muscle as well as the course of atrophy of denervation? The answer to the second question was positive; answer to a third question was desirable: 3. Is it likely that an optimal duration and number of daily treatments by electrical stimulation can be found?

The answers to all the questions were positive. As far as work output, endurance and optimal stimulation were concerned, stimulation for 30 minutes once

daily had slight beneficial effect. Stimulation for 30 minutes twice daily had greater beneficial effect. Stimulation for 5 minutes every half hour for an 8-hour day, starting at 8 a.m. and continuing until 5 p.m., with 1 hour of rest at noon, had substantially as much beneficial effect as had longer periods of stimulation each half hour.

As for atrophy, determined by muscle weights 25 to 30 days after denervation, electrical stimulation reduced but did not prevent it.

Stimulated denervated muscle was more efficient than was unstimulated denervated muscle but neither was as efficient as was comparable intact muscle.

For reprints, write Section of Publications, The Mayo Clinic, Rochester, Minn.

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Strength Decrement Index: A New Test of Muscle Fatigue

H. Harrison Clarke, Ed. D.
Eugene, Ore.
Clayton T. Shay, D.P.E.
and
Donald K. Mathews, D.P.E.
Springfield, Mass.

Basic Concept

The Strength Decrement Index (SDI) is proposed as a test of muscle fatigue. The basic concept of this test is that an immediate effect of fatiguing muscles is to reduce their ability to develop tension. This phenomenon is the same as the muscular weakness experienced by the traveler after carrying a heavy suitcase for some distance.

A demonstration of the strength decrement effect of fatiguing exercise on the elbow flexor muscles has already been reported.[1] In this study, the elbow flexor muscles were fatigued through single-bout exercise sessions on the Kelso-Hellebrandt ergograph in accordance with technics previously described.[2] Cable-tension elbow flexion strength tests were given to each subject 30 seconds after exercise, and again at five-minute intervals for some time to note the strength recovery rate.

With a weight load on the ergograph equal to three-eighths of each subject's elbow flexion strength, the initial drop, 30 seconds after exercise, was pronounced (29 to 32 per cent of pre-exercise strength). At seven minutes 30 seconds after exercise, the strength loss was approximately 13 per cent; at 17 minutes 30 seconds, approximately 10 per cent; and at 42 minutes 30 seconds, about 4 to 5 per cent. In one instance, the subjects were followed for two hours after ergographic exercise without complete return to their mean pre-exercise elbow flexion strength. This study, therefore, justified the hypothesis that an immediate effect of fatiguing muscles is to reduce their ability to apply muscular strength; and, furthermore, that degrees of muscular fatigue are reflected in changed strength scores.

Application of the SDI

The Strength Decrement Index was devised as the proportionate loss of strength in a given muscle group resulting from physical exertion. The formula for its computation is:

$$SDI = \frac{Si - Sf}{Si} \times 100$$

in which:

Si = Initial strength: taken before exercise

Sf = Final strength: taken after exercise

The application of the SDI has been made in pack-carrying and swimming studies. Each of these will be described briefly.

Pack-Carrying Study

The authors utilized the SDI to determine the fatigue effect of various

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Research Professor, School of Health and Physical Education, University of Oregon.

Acting Director of Graduate Study, Springfield College.

Graduate Division, School of Physical Education, Springfield College.

muscle groups in marching and carrying military packs under field conditions.[3] An outdoor course of 1.25 miles over rough and hilly terrain was laid out; by repetition of this course six times, the distance of each march was 7.5 miles. The rate of march was 2.5 miles in 50 minutes, with a ten minute stop for retesting. The 30 subjects participating in the research were provided with regulation army clothing and equipment, including rifles. The packs were of standard types issued by the U.S. Army Quartermaster Corps.

A preliminary march and six experimental marches were conducted. For each experimental march, variations were made in the amount of weight carried, the pack, and the location of the load on the body. Only one such factor, however, was changed at a time, so that the effect of one variation would be uninvolved with the others.

The strength of the following eleven muscle groups was tested immediately before each march and at the end of each 2.5 miles during the march: Shoulder elevators, pectorals, trunk flexors and extensors, hip flexors and extensors, knee flexors and extensors, ankle plantar flexors, and right and left grip. Significant mean strength decrements were found in all but three of these muscle groups (pectorals, right and left grip), although the specific group and the amount of involvement varied for the different marches. Statistical significance was tested by application of the null hypothesis to the comparison of means.

To illustrate the utilization of the SDI as a means of evaluation of the muscular fatigue effects from pack carrying, the results of the final 7.5 mile march are presented. In this march, the subjects carried a rucksack with an overall load of 61 pounds. (The SDI's for the tested muscle groups and t's representing the difference between pre- and post-exercise strength means appear in table 1. For the 30 subjects, t's of 1.70 and 2.46 are statistically significant at the .05 and .01 levels of confidence respectively.[4])

Table 1: Mean Strength Decrement Indices from 7.5 Mile March with Rucksack and 61-Pound Military Load

Muscle Group	SDI	t
Shoulder elevators	10.10	2.79
Trunk flexors	8.08	4.67
Trunk extensors	14.64	4.53
Hip flexors	5.35	2.45
Hip extensors	7.75	1.67
Knee flexors	6.46	2.47
Knee extensors	——	——
Ankle plantar flexors	6.58	2.86

All but one of the muscle groups (knee extensors) suffered statistically significant losses in strength from this march. The greatest strain was apparent on the trunk muscles. The strength decrement effects on the other muscle groups were about the same, except the hip extensors which had a lower t-ratio. In reviewing the results of all the marches, the shoulder elevators were significantly affected only when the loads were carried low on the back, as with the rucksack. Similar results occurred when the combat pack was carried low on the back. The immediate effect of strength loss for this muscle group, however, is not clear inasmuch as the shoulder-elevation strength test was given last in the series of tests each time. Thus, approximately eight minutes intervened after the march was terminated before these muscles were tested. The estimated mean loss 30 seconds after exercise is 20 per cent.

Swimming Study

In a doctoral dissertation at the University of Oregon, Davis[5] studied among other things, the SDI's resulting from swimming 200 yards for time. The six muscle groups tested were: Shoulder flexion and extension, hip flexion and extension, and knee flexion and extension. These tests were administered initially at the time of the subject's first competitive swim, when unconditioned; and, again, after five weeks of intensive training, when in a conditioned state (table 2).

The swimmers increased their times on an average of 23.7 seconds during the five weeks of training and conditioning. The overall strength loss was 2 per cent less on the last swim. Thus, the

Table 2: Strength Decrement Indices of College Students Obtained from Swimming 200 Yards for Time

	Strength Decrement Indices	
Muscle Groups	Unconditioned	Conditioned
Shoulder flexion	13.98	11.11
Shoulder extension	22.22	18.23
Hip flexion	17.63	8.79
Hip extension	12.04	14.86
Knee flexion	12.99	12.46
Knee extension	6.97	7.54
Means	14.34	12.46

effects of these all-out exertions were nearly the same, the improvement in performance being reflected in better swimming times, rather than much less fatigue.

For individual swimmers, SDI's for various muscle groups were as high as 50. However, the greatest mean loss of strength was 22.22 per cent for the shoulder extensor muscles on the first swim; these same muscles, which are the arm pulling muscles in swimming, also had the greatest mean loss on the last competitive swim.

Conclusion

As a consequence of these studies, the Strength Decrement Index is proposed as a useful test in evaluating the effect of local fatigue upon muscle groups: Muscle fatigue is accompanied by loss in ability to develop tension; the amount of this loss can be measured, as this amount varies in relation to the degree of fatigue, the proportionate strength loss may be utilized as an indicator of the amount of fatigue.

For reprints, write Dr. Clarke, School of Health and Physical Education, University of Oregon, Eugene, Ore.

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Breathing Exercises in Pulmonary Emphysema and Allied Chronic Respiratory Disease

Alvan L. Barach, M.D.
New York City

This paper describes the breathing exercises employed in our clinic for the treatment of pulmonary emphysema and allied chronic respiratory diseases. The physiological background upon which these measures depend are presented without full discussion of the pathophysiology of the clinical entities themselves.

Introduction—Previous Studies

The importance of attempts to restore diaphragmatic function by breathing exercises was recognized by Hofbauer,[1] whose method of aiding the recoil of the lungs by voluntary contraction of the muscles of the abdomen during the expiratory cycle has been adopted by a number of investigators in this field.[2-9] Manual compression of the lower thorax and upper abdomen during expiration was subsequently recommended as an additional method of facilitating a more complete emptying of the alveoli.[5,10] Hofbauer[1] and others[5,6] also employed a whistling-type of expiration in which air was slowly delivered from the lungs. The value of posture in promoting diaphragmatic respiration was emphasized by Heckscher[11] who pointed out that the erect military carriage was responsible for keeping the lungs in an inspiratory position. This view was supported by findings of an increase in residual air in men who assume a lordotic stance, that is with the shoulders drawn back and the abdomen sucked in, as compared to an easy standing position.[12] In the leaning-forward posture, the tension of the abdominal muscles is relaxed with presumably less interference with inspiratory descent of the diaphragm.

Cooper[13] in 1839 and Duchenne in 1867[14] described diaphragmatic respiration as being superior in ventilatory effectiveness to that of the chest musculature. Heath[15] in 1919 found that the lower lobes of the lungs were inflated in the main by excursion of the diaphragm. In a study of the incidence of chest complication after surgical procedures, Hawkins[16] reported that the vital capacity was reduced 60 per cent with complete immobility of both leaves of the diaphragm. Herxheimer[17] and Wade and Gilson[18] demonstrated that the movement of the reserve of air was proportionate to the degree of movement of the diaphragm. In normal subjects tilted 45 degrees downward, thorax to head, the diaphragm was elevated approximately 6 cm. into the chest, with a marked decrease in lung volume and an increase in reserve diaphragmatic respiration.[18]

Reich[19] in 1924 originally showed that introduction of air into the peritoneal cavity resulted in 3 cm. elevation of the diaphragm, with a corresponding increase in its excursion and relief of dyspnea. Pneumoperitoneum as a treatment for patients with pulmonary emphysema was considered to be beneficial by most investigators in the majority of cases. Among the physiological effects noted are a decrease in lung volume due mainly to a decrease in residual air; a variable increase in the vital capacity and the maximal breathing capacity; the minute volume of breathing was lowered or unchanged, and the arterial oxygen saturation increased in some cases.[20-25] The venous pressure was diminished,[20] but in our studies this was noted only in those cases where dyspnea was relieved and diaphragmatic motion was restored.[27] Increasing the intra-abdomi-

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Clinical Professor of Medicine, Columbia University, College of Physicians and Surgeons; from the Department of Medicine, Columbia University, College of Physicians and Surgeons and the Presbyterian Hospital.

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nal pressure by the application of a low abdominal belt was found to result in similar although less marked changes, namely, an increase in the height and excursion of the diaphragm, and with improvement in dyspnea.[39-41]

Recent Physiological Studies on Diaphragmatic Function

Studies on the use of the head-down position in patients with pulmonary emphysema revealed the following specific effects which resulted from shifting from the erect sitting position to one in which the thorax was tilted head-down approximately 20 degrees. An increase in elevation of the diaphragm of 3 to 5 cm. with a corresponding increase in its excursion; an immediate decrease in pulmonary ventilation of 20 to 25 per cent and a corresponding relief of dyspnea in a high majority of cases, and improved diffusion and perfusion as a consequence of selective ventilation of the lower lobes of the lungs. Since the arterial oxygen saturation and the pH of these cases were either unchanged or elevated; the pCO_2 either unchanged or decreased in the presence of such a marked lowering of the minute volume of breathing, the conclusion that diaphragmatic breathing in the cases tested resulted in a more efficient exchange of oxygen and carbon dioxide in the alveoli at the bases of the lungs was reached.[42] A striking example of the importance of selective pulmonary ventilation is seen in the prompt disappearance of the inefficient, burdensome ventilation characteristic of many patients with pulmonary emphysema. Even though lung volume and bronchial diameter were reduced by the head-ward tilt of the thorax, trapping of air did not take place. The lung relaxation pressure was increased by the upward visceral pressure on the diaphragm. A marked lowering of the pulmonary ventilation and a resultant lowering of the pressure drop between the alveoli and the larger bronchi was noted. The work of breathing was conspicuously decreased.

When the patient's posture is changed from erect sitting to a bending forward position of approximately 40 degrees, the pulmonary ventilation is also generally decreased but to a lesser extent, i.e., approximately 8 per cent, accompanied by an increase in lung volume of approximately 10 per cent of the vital capacity. In current and unpublished studies, the application of a lower abdominal belt when combined together with the leaning-forward position resulted in a more marked (20 per cent) lowering of the pulmonary ventilation in most instances. Ventilation decreased from 10,440 to 8550 cc. per minute incident to a change from thoracic to abdominal (diaphragmatic breathing) induced by increasing the intra-abdominal pressure by a belt and the leaning-forward position (fig. 1). It appears to be evident that procedures which decrease the downward pull of the viscera on the diaphragm will aid recoil of the lungs, thereby improving diaphragmatic excursion and relieving dyspnea.

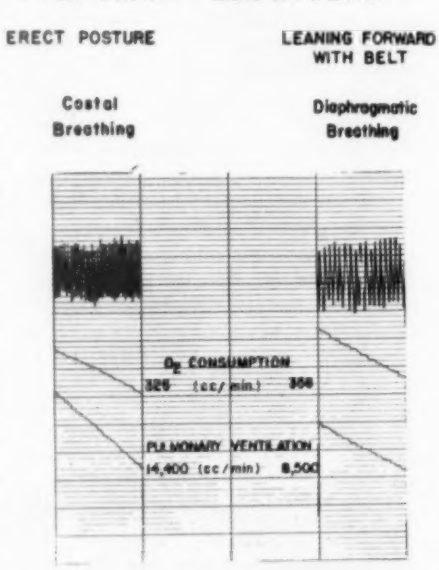

Fig. 1 — Lowering of pulmonary ventilation in a patient with pulmonary emphysema due to leaning-forward posture and G-B Emphysema Belt. Ventilation sitting erect, with costal breathing is 14,400 cc. per minute; ventilation leaning forward 40 degrees with emphysema belt attached and diaphragmatic breathing is 8,500 cc. per minute.

In addition to the favorable effects of initiating diaphragmatic respiration on dyspnea, ventilation of poorly aerated alveoli at the bases of the lungs provides a more efficient cough mechanism. When air flow does not reach alveoli distal to occluding mucous plugs, these secretions are retained even in the presence of vigorous coughing efforts. Unfortunately, the usual upper intercostal type of ventilation seen in patients with emphysema and allied respiratory diseases may be accompanied by actual ascent of the diaphragm during inspiration with rebreathing from upper to lower lobes and inadequate aeration of the alveoli at the bases. Table 1 lists a variety of diseases characterized by impaired bronchial drainage. The therapeutic methods employed include not only the head-down position but also diaphragmatic breathing and other procedures such as manual compression of the chest, deliberate coughing after inhalation of bronchodilator aerosols, and the recently developed mechanical method of blowing secretions from the lungs, exsufflation with negative pressure.[33,34] Table 2 presents an outline of the management of pulmonary emphysema which includes physical methods of increasing effectiveness of breathing, and procedures employed in elimination of bronchial secretions and bronchospasm. Since all these measures will not be discussed in detail, it is of interest to point out that breathing exercises play a role with other therapeutic programs in the treatment of chronic respiratory disease as well.

Although symptomatic improvement has been reported from the use of voluntary abdominal contraction during expiration, tests of respiratory function have not reflected the benefit expected from subjective reports of the patients themselves.[9] However, respiratory function tests, such as the vital capacity and maximal breathing capacity, have not in our study too, revealed the benefit derived from diaphragmatic respiration. Determination of comparative response to the inhalation of air and 100 per cent oxygen has seemed to mirror clinical improvement in a more satisfactory way than other measurements.[35-37] The technic of obtaining pulmonary ventilation with level respiratory graphs and an automatic maintenance of the oxygen concentration when breathing air or high oxygen mixtures has been previously described[38], but a somewhat simpler approach to the device is shown in figure 2. The principle of this technic depends on an inlet of oxygen into the spirometer when a leveling device to which it is attached falls below the previous spirometer level. By employing an additional spirometer for storage of oxygen, simultaneous measurements of the oxygen consumption and the pulmonary ventilation may be obtained on the same record.

Table 1: Physical Methods Employed to Facilitate Drainage in Respiratory Tract Infections

METHODS

a. Postural drainage
b. Head-down position
   Thorax tilted headward 15 to 20 degrees
c. Exsufflation with negative pressure
d. Inhalation of broncho-dilator aerosols
e. Deliberate coughing
f. Manual compression of lower chest
g. Diaphragmatic breathing

DISEASES IN WHICH PHYSICAL METHODS MAY AID IN CONTROLLING INFECTION

1. Chronic bronchitis
2. Bronchial asthma
3. Bronchiectasis
4. Pulmonary emphysema
5. Poliomyelitis
6. Myasthenia gravis
7. Neurological disorders
8. Post-operative conditions
9. Pulmonary atelectasis
10. Sinusitis

Table 2: Management of Pulmonary Emphysema

1. PHYSICAL METHODS OF INCREASING EFFECTIVENESS OF BREATHING
   a. Instruction in diaphragmatic breathing
   b. Tilting thorax headward 15 to 20 degrees
   c. Forward bending posture
   d. Elastic 2-band abdominal support (Spencer Gordon-Barach)
   e. Manual compression of lower thorax

2. ELIMINATION OF BRONCHIAL SECRETIONS AND BRONCHO-SPASM
   a. Inhalation of broncho-dilator aerosols
   b. Aminophylin, Ephedrine, Iodides, Ipecac
   c. Deliberate non-forceful coughing
   d. Cortisone, ACTH, Ether, Fever, Demerol, Fowlers solution
   e. Exsufflation with negative pressure, bronchoscopy

Outline of physical methods of increasing effectiveness of breathing and procedures employed in elimination of bronchial secretions and bronchospasm in patients with pulmonary emphysema.

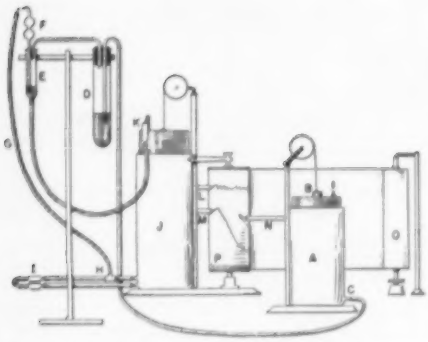

Fig. 2 — Device for automatic maintenance of the oxygen concentration of air or oxygen enriched atmospheres with simultaneous measurement of the oxygen consumption, and provision of level respiratory graphs: (a) Spirometer bell containing oxygen; (b) weight; (c) oxygen outlet leading to water trap; (d) water trap; (e) water valve; (f) trap; (g) rubber tube; (h) oxygen inlet; (i) flutter valves; (j) spirometer bell; (k) leveling bulb; (l) respiratory pen; (m) Reichert counter; (n) oxygen volume pen; (o) paper role, and (p) timer graph.

In our experience, voluntary contraction of the abdominal musculature infrequently becomes an automatic habit, which is spontaneously carried out by the patient during exertion. The procedure we employed to develop diaphragmatic breathing depends upon relaxation of the abdominal wall; the deliberate cultivation of the habit of diaphragmatic breathing, posture, and in most cases, the use of the Gordon-Barach Emphysema Belt.* The patient is in most instances placed head-down, preferably 15 to 22 degrees; if supine, a 10 pound sandbag weight is applied to the abdomen or pressure is exerted by the G-B belt. The patient is told that protrusion of the abdomen during inspiration represents the use of the diaphragm. In the head-down position, the patient quickly observes, with one hand on the chest and the other on the abdomen, that diaphragmatic breathing is taking place. He is thereupon instructed to stop, as much as he can, any use of the upper intercostal or neck musculature. The training is continued in the supine position, and later in a chair leaning forward at an angle of approximately 40 degrees. During the training, the patient still retains the hand on the lower abdomen thereby witnessing the correct, diaphragmatic abdominal protrusion, as contrasted to the incorrect elevation of the chest during inspiration.

The practice of diaphragmatic breathing is continued by the patient in the hospital or at home during periods of one-half to one hour in duration, two or three times daily or longer, if the patient is able to do so. In the erect-standing position, the flattening and tension of the abdominal musculature appears to prevent satisfactory descent of the diaphragm. The patient is instructed to relax, lean forward and maintain as far as possible, the degree of diaphragmatic movement previously obtained in the supine and head-ward tilt of the thorax positions. In the standing posture, the aid of the emphysema belt is generally required to enable the patient to carry on satisfactory diaphragmatic excursion. In patients developing dyspnea during the night, a 10 pound sandbag or the belt is helpful at times when strapped to the lower abdomen while the patient is lying supine. Unfortunately, many patients with pulmonary emphysema are found in the wards with the Gatch of the bed elevated. This position is useful to patients who have cardiac disease or to those who find it an effective posture for coughing. However, even in patients with bronchial asthma, the ventilation as well as the dyspnea of the patient is relieved if the thorax is tilted sufficiently headward to initiate diaphragmatic breathing. The degree of tilt depends in part on the weight of the liver, spleen and other organs. Despite the fact that the vital capacity is lowered in cases presumed to be orthopneic because of bronchospasm, the increased exchange of oxygen and carbon dioxide provided diaphragmatic breathing is initiated, does, in fact, relieve shortness of breath.

The clinical and physiological results of diaphragmatic breathing in several hundred patients with pulmonary emphysema observed since 1947, have led

*Manufactured by Spencer, Inc., New Haven, Conn.

us to believe that change from an upper thoracic to a predominantly diaphragmatic respiration is the single most valuable contribution of the various physiological methods employed to improve the mechanics of breathing.[32,33,37,39] Although the electrophrenic resuscitator was found to be a dramatic and enlightening technic of initiating diaphragmatic respiration, the method of employing the head-down position is simpler and equally effective. However, patients with pulmonary emphysema do not abandon the inefficient type of ventilation accomplished by the shoulder girdle and the neck muscles unless diaphragmatic breathing does actually take place. It may be pointed out that since the surface area of the diaphragm is approximately 270 square cm., a rise of 2 cm. would contribute a substantial increase in tidal volume, even though the maximal excursion took place in its central area.

Although the fluoroscopic table is the most efficient method employed in determining the head-down position that will result in maximal diaphragmatic excursion without excessive pooling of blood in the head or in the mediastinum, a simpler method used with hospitalized patients is to elevate the foot-end of the Gatch spring, and place the head of the patient in the middle of the bed with the trunk at a head-down angle of 16 to 22 degrees. One precaution to be exercised is not to permit the legs of the patient to dangle downward over the foot of the bed since the abdominal wall might then be tightened to such an extent as to interfere with easy diaphragmatic breathing. Elevating the foot of the bed with high shock blocks may not be adequate unless the additional use of pillows under the trunk, the emphysema belt or a sandbag is employed.

Manual Compression of the Chest and Lower Abdomen

Manual compression of the lower four ribs and the upper surface of the abdomen underneath the ribs anteriorly is used in the latter half of expiration to facilitate expiratory ascent of the diaphragm. This maneuver is now employed in our clinic as a sudden forceful pressure repeated three times during the expiratory cycle not only to decrease alveolar overdistension but to produce a high expiratory flow rate and thereby facilitate the movement of secretions from the smaller bronchi into the upper respiratory passageway.[20,33] The operator generally stands behind the patient, using the palms of the hands which should be extended, to press simultaneously upward underneath the anterior ribs and inward along the lateral rib margins to produce the quick chest and upper abdominal compression. The maneuver is particularly effective after inhalation of bronchodilator aerosols. In experimental studies, it has been shown that the vital capacity may be increased from 200 to 1000 cc. immediately after ten compressions even in the absence of epinephrine compounds used as a bronchodilator.[20,34]

The patient is taught to perform the maneuver without assistance. If he is unable to compress the chest consecutively during ten expirations, he may allow a minute or two between each procedure. Sitting comfortably in a chair, often bending slightly forward, he can place the palms of both his hands partly under the ribs and partly along the lateral margin and elevate his own diaphragm during the latter part of expiration. The result of this mechanical upward pressure on the diaphragm is frequently revealed by audible wheezing sounds as air is emitted from the lungs. Although noticeable subjective relief may ensue, the patient is informed that a repetition of the maneuver may be required in three or four hours, especially if undue physical exertion has taken place.

Pursed-Lip Breathing

A whistling, humming sound made during expiration was recommended by Hofbauer,[1] Schutz[8] and Livingston[8] for patients with bronchial asthma and pulmonary emphysema. Livingston instructed the patient to take a quiet inspiration followed by a long expiration with lips partially closed to make an "F"

sound. In our use of pursed-lip breathing, a full inspiration followed by a slow expiration against the pressure induced by constricting the lips is considered an advantage. The degree of pressure is subject to considerable variation, since it is generally increased in respect to the backward pressure employed as dyspnea itself is more severe.

The physiological effects of this type of breathing deserve consideration in order to understand its varied usefulness. It is of interest to note that lumbermen, stone-cutters and mountain climbers in various parts of the world, spontaneously turn to pursed-lip breathing in expiration in a manner similar to that employed by patients with pulmonary emphysema. In studies on expiratory pressure breathing, it was found that the degree of bronchial constriction determined by lipiodol x-ray measurements of the bronchial diameter was considerably lessened during expiration by a positive pressure of 6 cm. of water.[40] The degree of widening of the diameter of the bronchi was partly due to increase in lung volume and increase of intra-bronchial pressure. The advantage of this type of slow expiration following a full inspiration is that air would leave the lungs through a more patent bronchial passageway, and with more time allotted to the expiratory cycle.

Pursed-lip breathing was also found to result in a rise of peripheral venous pressure of 60 mm. H_2O during the expiratory cycle.[38] It would appear that the maneuver is used as a method of preventing undue congestion of the lungs in normal individuals undergoing severe exertion as well as in patients with cardio-respiratory disease. This effect is comparable to the use of pressure breathing in the treatment of pulmonary congestion and pulmonary edema. The use of pursed-lip breathing is advocated not only during exercise but also in asthmatic dyspnea, in which the sibilant rales may often be heard to diminish or disappear during the period of its use. Of interest is the fact that one frequently sees patients with pulmonary disease in whom psychosomatic factors are operating and in whom rapid respiration with the mouth open results in audible wheezing. This is particularly observed in patients who seek disability. The sinister consequences are obvious, namely, increased dyspnea as result of the lack of backward distending pressure on the smaller bronchi; a more rapid pressure drop from the alveoli to the cartilagenous ends of the bronchi which promotes bronchial closure, as well as a lowering of the peripheral venous pressure of 15 to 20 mm. water during this type of rapid, open-mouth breathing.[38]

The advantages of a slow expiration induced artificially by pursed-lip respiration have been clarified by the studies on expiratory air flow in which it is shown that rapid breathing or coughing results in bronchial closures as a consequence of a relative increase in intra-alveolar over intrabronchial pressure.[41-43] Although decrease in outward lung traction on the bronchial wall is a factor responsible for retarded air flow, a major physiologic handicap in pulmonary emphysema is bronchial constriction as revealed previously by clinical relief of dyspnea after inhalation of bronchodilator aerosols, and helium-oxygen mixtures and pressure breathing; and spirometric records which have shown increases in maximal minute ventilation and in expiratory volume flow rates as well as a lowering of the minute volume of respiration after inhaling epinephrine (1 per cent) or racemic epinephrine (2.25 per cent) (Vaponefrin Isuprel, Dylephrin) or other compounds.[30,39,44-48] The advantage of pursed-lip breathing, therefore, includes a more efficient emptying of the alveoli as a result of a widened bronchial diameter and an increased time during which the inspired air may be exhaled, in addition to the preservation of a more favorable relation between the elastic pressure of the lungs which tends to keep the bronchi open in comparison to the pressure gradient between the alveoli and the large bronchi.

Breathing Exercise Appendix for Patients with Pulmonary Emphysema

These directions apply to the patient with pulmonary emphysema or allied

respiratory diseases to the extent indicated by a physician.

1. On *awakening* the patient should reach for the nebulizer, of the fine particle size type and in which there would be 10 to 12 drops of a bronchodilator solution, such as 1 per cent epinephrine or, preferably, 2.25 per cent racemic epinephrine (Vaponefrin); if patient is resistant to epinephrine, 1 per cent Isuprel, or similar compounds with addition of an anti-cholinergic drug, i.e., atropine such as Dylephrin, should be used. The rubber hand bulb, squeezed vigorously three times during the course of a deep inspiration, is generally repeated five to seven times. In patients who have equipment for continuous nebulization, 0.5 cc. of the bronchodilator solution is mixed with 2 cc. of normal saline and inhaled with a mouthpiece or mask rebreathing apparatus during a period of 12 to 15 minutes.* In some instances one-half of the solution is inhaled before breakfast and one-half afterwards. The patient with pulmonary emphysema and at times those with bronchial asthma, may have severe attacks of difficulty in breathing in the morning when moving about. This may be due to spasm of the bronchi but more often is a result of obstruction of the bronchi produced by the mucus that has accumulated during the night. It is therefore important, in order to prevent these attacks of dyspnea, to accomplish a dilatation of the bronchi and elimination of the mucus before any of the usual morning exercise takes place.

2. Manual compression of the lower ribs and upper abdomen is carried out immediately after the nebulizer is used with the patient still lying quietly in bed or, if desired, sitting up. The purpose of this maneuver is to squeeze excess air out of the lungs and to propel the mucus in the dependent parts of the lower and smaller bronchi into the upper respiratory tract where it might be more readily expectorated. Both hands are placed on the antero-lateral lower ribs and on the upper abdomen. The position may be determined by leaving a hand's length space between the two hands which should be kept fully extended and not bent during any part of the maneuver. The thumb, index and middle fingers are pressed vigorously inward against the lower three ribs; the fourth and fifth fingers are pressed upward and backward against the abdominal wall. If the hands are kept straight and rigid, undue pressure on the muscles of the abdomen will not take place. Manual compression, which is carried out during the latter half of expiration, should consist of sharp, abrupt vigorous compressions, generally repeated consecutively ten times. In patients who are weak or short of breath, an interval of one or two breaths may afford comfort between each chest compression. A nurse, physical therapist or assistant may be required to secure maximum effectiveness for this maneuver. During this expiratory compression, rales may be heard before the mucus is expectorated. Manual compression appears to be more effective if it is combined with pursed-lip breathing.

3. Deliberate coughing should then be initiated whether or not mucus has been eliminated during the two previous procedures. Coughing should not be violent since forceful coughing results in the development of too much pressure within the chest cavity and premature closure of the smaller bronchi rather than expulsion of mucus! The cough should follow a deep inspiration and should therefore be of slight or moderate degree. In order to develop a faster velocity of air from the lungs, it is helpful in some instances, to employ manual compression at the same time as the cough.

If there is still evidence of mucus retained within the chest by the presence of audible gurgling sounds during the cough, the foregoing three procedures should be repeated namely, inhalation of a bronchodilator aerosol, manual compression and deliberate coughing. The procedures should be repeated preferably at four p.m. but no later than

*The mouthpiece apparatus is made by the Vaponefrin Co., Upper Darby, Pa.; the mask, with a positive pressure attachment and inspiratory disc removed, by the O.E.M. Corp., East Norwalk, Conn.; air pumps by the Malhof Corp., Avenel, N.J., and Medical Specialties, Boonton, N.J.

six p.m. if at all possible, and once again during the latter part of the evening before retiring.

4. Diaphragmatic breathing is practiced after breakfast as well as after other meals and as often as time permits (at least one-half hour three times daily) until the patient has become experienced in the use of diaphragmatic respiration. The easiest and by far the most effective method of learning to breathe with the diaphragm is to place one's self in a position in which the chest is inclined toward the head at an angle between 12 and 25 degrees. In hospitalized patients, the foot-end of the Gatch may be sharply elevated so that the patient's thorax is inclined toward the middle of the bed. A pillow should be placed under the patient's head. The knees should be drawn forward from the foot-end so that tension on the abdomen does not occur. Initiation of diaphragmatic movement often takes place spontaneously but it is necessary to be aware of the fact that inflation of the chest by the muscles of the neck, shoulder girdle or upper thorax should be stopped. Breathing should be confined exclusively to the diaphragm which is manifested by its protrusion during inspiration.

Other methods of achieving a headward tilt of the thorax include high shock blocks under the foot of the bed, additional pillows under the lumbar vertebral column, employment of hydraulic bed lifters,* glamour boards or chair under the foot of a hospital bed or cot. Pillows should be put under the head, but not under the thorax, in order to take full advantage of the pressure of the liver, spleen and other organs which push the diaphragm upward during expiration. One of the primary difficulties handicapping patients with emphysema is that the elastic quality of the lungs is impaired to such an extent as to interfere with raising of the diaphragm into the chest during expiration. The head-down position allows the weight of the abdominal organs to accomplish this naturally. Inspiration is then automatically accomplished by contraction of the diaphragm which is a relatively normal organ except for the atrophy induced by disuse, which may be largely corrected.

After practicing in the head-down position, the supine position is used to carry on diaphragmatic breathing, i.e., of such a type that the abdomen will protrude upward during inspiration. This may be facilitated by a conscious contraction of the abdominal muscles during expiration but unfortunately, conscious abdominal muscular contraction is not apt to become automatic often enough to recommend its use especially at this time. A more satisfactory aid is the employment of a weight on the abdomen such as a 10 or 12 pound sandbag, heavy books, or the application of an abdominal emphysema belt. Belts of this type should never be placed above the umbilicus! Adequate elevation of the intra-abdominal pressure to float the abdomen upward is obtained by low abdominal belts. Those which reach near the ribs interfere with diaphragmatic descent during inspiration. The Gordon-Barach Emphysema Belt contains two elastic metal springs that store the energy during inspiration as a result of diaphragmatic contraction to aid recoil of the lungs on expiration.

The belt is put on after the patient has eaten breakfast. He then inspires against the applied pressure which is moderate in degree at first and is later increased by tightening the straps. It is generally helpful to place one on the abdomen and one on the chest in order to feel as well as see the degree of chest movement to be abandoned and the extent of diaphragmatic movement to be increased.

Abdominal breathing is then practiced in the sitting position, first leaning forward at an angle of 45 and later 15 degrees, never sitting or for that matter, standing erect. The leaning-forward position is similar to the head-down position. Weight of the viscera does not exercise as much force to oppose expiratory contraction of the lungs as is evident when one leans forward or stands

*Zimmer or Du Puy Companies, Warsaw, Indiana.

erect. If man were to walk with the thorax bent as far forward as does the gorilla the diaphragm could move almost horizontally and the downward pull of the liver and spleen would handicap diaphragmatic excursion very little. Of all the recommendations listed, the most important is thought to be the program outlined for diaphragmatic breathing. Massage is of no value in development of the diaphragmatic muscle; intermittent pressure breathing devices which "breathe for you" are also useless in this respect. Nothing except active exercise results in hypertrophy of muscle, such as that induced by the head-down position, abdominal weights and a spring elastic emphysema belt.

As the diaphragm becomes stronger, tightening of the belt in the lower abdomen may be increased since the elevated intra-abdominal pressure will tend to exert a beneficial effect by raising the diaphragm higher during expiration, and in that way, assist recoil of the lungs. A tight belt should be no disadvantage during inspiration when the diaphragm is able to contract against the arbitrarily imposed intra-abdominal pressure. Table 3 indicates that a patient with pulmonary emphysema of moderate degree could produce maximal excursion of movement of the diaphragm of 2.0 cm. when standing erect, 3.6 cm. supine, and 5.3 cm. head-down. This response illustrates the effect of the downward pull of the viscera on an untreated subject.

Table 3: Effect of Posture on Diaphragmatic Excursion

Position	Diaphragmatic Excursion cm.*
Standing erect	2.0
Supine	3.6
Head down 16°	5.3

*Average of right and left anterior leaves of diaphragm.

Decreasing downward pull of the viscera due to change in posture from standing erect to supine and head-down posture results in increasing diaphragmatic excursion in a patient with pulmonary emphysema.

5. The Gordon-Barach Emphysema Belt was designed with two elastic metal bands placed on a pad, which is connected by suitable straps to a cotton fabric covering around the back. The lowest spring is drawn more tightly than the upper; the effect of tightening both of them is an inward and upward pressure on the abdominal wall. Exerting its effect by the increase of intra-abdominal pressure, the belt should be adjusted in such a way that the patient finds, at first supine and later standing in a bending-forward position, abdominal protrusion during inspiration is achieved.

The belt is worn from the time the patient arises until he retires. In severe cases of dyspnea it may at times be applied during the night, or if necessary, a 10 or 12 pound weight may be used instead. It should be recognized that the belt is of no value if the breathing continues to be conducted by the muscles of the upper chest, shoulder girdle and neck. The purpose of the belt is to elevate the dome of the diaphragm upward into the chest so that it assumes a rounded convex shape. Under these circumstances, it contracts efficiently by pulling the bases of the lungs downward and by creating a negative pressure in the chest. Excursion of the diaphragm and effective ventilation of the lower and central parts of lungs is consequently enhanced. Objectives achieved by abdominal breathing, which are aided by the emphysema-type belt, are not only increased capacity for exercise on exertion, but increased aeration of the air cells at the bases of the lungs. This subsequently increases the effectiveness of eliminating stagnant secretions.

It should be realized that the periphery of lungs, especially the apices which have only soft tissues to oppose distension of the lung during cough, are more apt to become distended than the regions of the lungs near the hilum. The lower lobes of the lungs have twice as much oxygen-diffusing surface as the upper lobes. An elastic pressure vest is at times used to restrict this upper thoracic motion.

6. Exercise of the abdominal muscles is of some importance in most cases of respiratory disease. Of the various methods employed, the use of the supine po-

sition with upward extension of the legs in a straight arc upward from the pelvis, first one, then the other, then both legs, carried out for three minutes three times daily, is the simplest. In many instances, bicycling maneuvers are also employed in the supine position.

7. In patients using an oxygen cylinder, an exercise program is of value in order to develop increased tone in the body muscles as well as to develop a training response in the circulatory system. A double-bent nasal tube is employed with a flow of 8 to 10 liters per minute of oxygen through a 30 to 50 foot length tube. At first, 50 steps are taken during the inhalation of oxygen, and 25 steps without oxygen. The number of steps walked each day is increased until approximately 1000 steps with oxygen are taken daily. When the exercise is concluded, it is desirable to maintain the flow of oxygen until the ventilation has decreased toward normal—generally three to four minutes. It will be found that most patients are surprised at the degree of walking ability made possible for them during oxygen inhalation. This practice is of value not only from the standpoint of increasing the capacity for exercise without undue fatigue or tachycardia, but also as a source of encouragement to the patient himself in carrying out the full regimen.

8. Pursed-lip breathing is an exercise in which a full inspiration is followed by a slow expiration with the lips partly closed so that increased effort is required by the abdominal and lower intercostal musculature to accomplish expiration. Patients with pulmonary emphysema and those with severe bronchial asthma are often unable to eliminate all the inspired air from the lungs during a conventional expiration. This type of breathing allows more time for emptying of the alveolar cells and, in addition, provides a wider lumen of the bronchi especially during the first half of expiration. It is used during periods of wheezing and dyspnea, when it will be noted that the sibilant rales heard in the chest frequently disappear. During exercise, pursed-lip breathing has the additional advantage of preventing an excessive amount of blood from entering into the heart and lungs. During physical exercise, the lips are held even more tightly closed so that greater effort is required to blow the air out through them. Although the expiration is prolonged, it should not be so lengthy as to result in a feeling of shortness of breath, since most of the air is delivered from the lungs during the early period of expiration when bronchi are relatively enlarged. However, the patient should realize that better parts of the lung will empty first. It is important that expiration be prolonged sufficiently to allow the more diseased areas to eliminate retained air because of the smaller elastic pressure behind them. As previously mentioned, pursed-lip breathing is uniformly employed along with manual compression of the abdomen.

9. Hyperventilation may be defined in this connection as breathing more than is actually necessary for the purpose of gas exchange in the lungs. The patient should never try to do the breathing exercise in which the lungs are expanded for the purpose of drawing in a great deal of air. The opposite of this action is to be followed, namely, breathing in as little as possible. Exertion, which should be terminated when shortness of breath begins, is facilitated by supporting the abdomen with the hands, compressing the lower chest and abdomen, and pursed-lip breathing. Bending forward to an angle of 45 degrees in either the standing or sitting position generally reduces shortness of breath provoked by undue exertion.

At times a nervous habit consisting of taking a deep breath from time to time is developed. This type of sighing respiration unfortunately appears to accustom the lungs to a larger volume of air than necessary so that the individual is later discontented with what is a reasonable volume of air in the lungs. The most effective method of dealing with undue hyperventilation includes the use of procedures which inaugurate exclusive diaphragmatic respiration, namely, the head-down and bending forward positions, or the embryonic or fetal position. In the latter posture, the patient

lies on his side without a pillow, the knees are drawn as far forward as possible, the hands are locked around the knees and the head is bent forward. It is surprising, at times, to see the diminution in the degree of asthmatic dyspnea as well as the decrease in the volume of breathing as a result of this procedure. Under these circumstances, the diaphragm is also elevated to a position where it can contract more efficiently. With better diffusion of oxygen and carbon dioxide, a lessened degree of air movement is required.

10. The employment of the measures described does not exclude the use of whatever therapeutic medical program may be indicated, such as the employment of iodides to produce a less viscous sputum or mechanical devices that blow out mucus from the lungs. The procedures listed may be more indicated in some cases than in others. Thus, in patients with bronchiectasis without spasm of the bronchi, the use of the head-down position for bronchial drainage, manual compression of the chest, and effective coughing, may be of greater value than inhalation of bronchodilator aerosols.

Summary

Breathing exercises are described which have been found useful in pulmonary emphysema and to a variable extent, in allied respiratory diseases such as bronchial asthma, bronchiectasis, chronic bronchitis and pulmonary fibrosis. A discussion of the physiologic basis for the following procedures including a new method of teaching diaphragmatic breathing; manual compression of the lower chest and upper abdomen; employment of an emphysema belt, and pursed-lip respiration is presented. Directions suitable for patient use are also outlined.

For reprints, write Dr. Barach, Columbia University, College of P&S, 620 W. 168th St., New York 32, N.Y.

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REMEMBER!

It's not too early to make plans for the annual meeting in Detroit.

Motivation Clinic for Chronic Neuropsychiatric Patients

Charles H. Reagan, M.D.
Tuscaloosa, Ala.

Activities Program

More than one year ago, the patient load of one of the Continued Treatment closed wards of the VA Hospital (Tuscaloosa, Ala.) was increased from about 160 to 185 patients. Before this change, the Occupational Therapy program for this ward consisted of a small group of ward workers; three groups of outside detail patients offering activities in gardening, landscape, and lawn care; one large arts and crafts clinic offering the full range of occupational therapy activities; one small industrial therapy group working in the laundry; and a small group working in Manual Arts Therapy. This program provided a fairly well-graded series of activities, through which the patient could progress from the habit training level up to the Manual Arts Clinic where he might receive instruction and guidance and participate in work situations somewhat near the employability level.

"Vegetative" Patients

True, we had noted that there was approximately one dozen patients of the foregoing groups who absolutely refused to participate in any of these activities. Dare we admit that we did not note them very much? After all there was the large majority of others who did respond in varying degrees to our rehabilitative efforts. Then, too, ward and occupational therapy personnel did from time to time use firm insistence in getting these patients to be present at the various activities, only to find a demonstration of their ability to do nothing here as well as on the ward.

"Sitters" was our term for these patients. Is further definition necessary? Within a few weeks after the increased patient load, the number of "sitters" had increased to 30 or 40 and we could no longer ignore them. They were described by the Chief of the Service as "vegetative." Surely there was some kind of occupational therapy that would aid in motivating these patients. But everything we had to offer had been tried again and again with recurrent failure. Clearly something different was needed.

Perhaps too much emphasis was placed on an activity as such. One writer who analyzed the current trends, technics, and tendencies in the field of group therapy noted that many ancillary technics of widely different persuasions had nevertheless been reported in the literature as being almost equally effective. He stated that perhaps each method had proved successful because it had elicited one or more of the "Ur-delusions" of man, "each of which, when skillfully invoked, is a powerfully-cathected therapeutic tool."[1] These "Ur-delusions" are the *Delusion of Personal Power;* the protean *Faith in Omnipotent Servants,* and the *Trust in Humanity.* We were impressed by his two fundamental technics of all therapy, "namely: 1) Render that which is neurotic no longer necessary or advantageous to the patient, and 2) help him to learn other ways of life that will prove (a) more roundly enjoyable; (b) more profitable to him in the long run; and (c) more socially acceptable and constructive." We felt that as part of the team, occupational therapy should at least offer something to help accomplish the second of these technics of therapy.

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Chief, Physical Medicine and Rehabilitation Service, VA Hospital.

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Where were the "colossal potentialities" of these patients?[2] Why did our workers attain some degree of success with a majority of their patients and fail so miserably with the "sitters"?

We have made an attempt to answer these questions. The following principles were recognized as applicable: The patient "should be treated in a dignified and friendly manner by the therapist. Small accomplishments on the part of the patient should be pointed out and recognition given. Reprimands and sarcasm should be avoided. In no case should the patient be given a sense of failure and for this reason he should not be given tasks which are beyond his capacity. A careful, graduated program with easy transitions is preferable to one that presents sharp increases in difficulty. Throughout the treatment process, emphasis should be on the positive (constructive) aspects rather than the negative (destructive) features."[3]

New Program Developed

The form of our program for these patients gradually took shape as we weighed the many complex factors with which we were dealing. We felt that "emphasis upon the importance and worth of individuality and the individual in action has deep significance in a study of therapeutic excitants," and also that "many therapeutic systems fail because they lack progressive provisions enabling the individual to perceive and appreciate definite goals and steps of improvement."[4]

The authority who classified the course of mental illness as "predisposing, precipitating, and perpetuating," could certainly accent the latter phase when speaking of our "sitters." Sewall states that, "Little can be done in adult life to modify predisposing factors. Precipitating factors are ordinarily of brief duration. The major problem in the treatment of emotional disorders, therefore, is dealing with those factors influencing the course of mental illness — the perpetuating ones."

"In the hospital management of psychiatric illness, especially those of a more chronic nature, many patients improve to the point of a 'good hospital adjustment' but fail repeatedly in attempts to return to community living. This raises the question as to whether hospital treatment programs contribute to the perpetuation of mental illness."[5] In formulating our plans for our motivation clinic we attempted to avoid those examples listed by Sewall as possible contributors to perpetuation of mental illness.

It was desired that a permissive atmosphere should prevail in the clinic. This aspect of client-centered therapy was believed to have important implications for occupational therapy for these patients. There would have to be limitations of course, but it was recalled that the leading exponent of this method of therapy proposed some limits.[6]

Many individuals, in person and through the literature, had contributed ideas and suggestions for our motivation clinic. But the most important person of all, our patient — what had he contributed? His physical presence, to be sure. Oh, yes, he was here all right, sitting on the ward, day in and day out. But surely there must be something else. We believed in Fromm-Reichmann's concept that man's tendency toward health is ever present, even though adverse conscious trends in his personality interfere with its effectiveness.[7] In our patients, this motivating force had certainly been inactive for a long time and the negative, adverse trends had apparently taken over.

While we recognized that the utilization of exact modalities was generally considered of secondary importance, our team felt that in the case of our "sitters" it was a close second. At least utilization of simple, uncomplicated skills was considered a must. The Motivation Center idea described by Freeman and Schwartz[8] was believed to be effective mainly with the acutely ill. We felt that our "sitters," who had been in the hospital for years, and practically all of whom had been through every conceivable therapeutic program the hospital had to offer, may have been over-

whelmed by what they may have considered unobtainable goals set for them. We would not permit the presence in our clinic of any activity that the patient could interpret as being beyond his ability.

Sanding of furniture for hospital use has been the principal activity. Poppy-making is also used. Other activities include shoe-shining, painting of tooth brushes, general house-keeping of the clinic, loopers and other simple craft activities which can be quickly completed.

Importance of the Psychiatrist

One might ask, "Where does the psychiatrist fit into this picture?" As a rule the psychiatrist is primarily concerned with treatment on an individual basis, but in the Motivation Clinic members of various ancillary disciplines contribute to the development of activity on the part of the patient and serve as a catalyst for the development of incentive. The psychiatrist has an opportunity for studying a group in action and can work out the various problems in interpersonal relationships which are bound to develop. The lack of a strict or fixed limit on the particular job any of the staff is to perform contributes to a considerable overlapping with the need for a close integration among the personnel. At meetings with the staff, the psychiatrist will be in a position to carry out what might be termed "group therapy," by which he can integrate the individuals into a closely-knit working organization where emphasis is less on any one type of activity or skill than on satisfying the constructive and expressive needs of the patient. Inasmuch as some type of relationship must be established with the patient before any type of activity is to be expected from him, it is obvious that the psychiatrist's job of working with the personnel in this direction will provide plenty of opportunity for him to help the workers do a better job. The need to fan immediately a spark of interest into a glowing flame of activity must be tempered by restraint and careful nurturing so that fears and anxieties will not be stimulated. The casual, permissive attitude where the patient is allowed to test the environment by merely watching what happens to the others, will pay off in the development of security in the personnel and their methods. The lack of authoritative pressure and the presence of multiple opportunities for expression located in a single area, enables the patient to test for himself the direction in which he would prefer to be active. No sense of failure develops when he shifts from one activity to another but he is encouraged and assisted in doing so as he gropes for expression and satisfaction.

Conclusion

It is to be expected that the rewards from such a program will be seen in the improvement of these long-hospitalized patients. This may take many forms as there develops an externalization of the patients' inner experiences into active, constructive performance. This is enhanced by the fact that it takes place in a group setting so that movement toward socialization is stimulated. Pride in achievement leads to pride in self with its maturating effect on the ego. Routine ward behavior and morale are enhanced, over-activity is reduced and movement toward other groups is developed. Personal hygiene and cleanliness are improved. The opportunities for an ever-widening sphere of activity and the broadening of the horizons of these patients offers a constant stimulus and challenge to them.

For reprints, write Dr. Reagan, Chief, Physical Medicine and Rehabilitation Service, VA Hospital, Tuscaloosa, Ala.

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Ultraviolet Irradiation and Cholesterol Metabolism

Rudolf Altschul, M.D.
Saskatoon, Canada

It is today generally agreed that the atheromatous type of arteriosclerosis is related to cholesterol metabolism. Cholesterol may play only a secondary role, whereas a constitutional or an acquired insufficiency of endothelium may be the real primary factor. It is, however, possible that even normal endothelium may be ultimately damaged if cholesterolemia is increased over long periods or permanently. Since it is at present impossible to change the state of endothelium by direct measures, it seems appropriate to protect it from noxious agents. The most rational approach will be the lowering of increased blood pressure or the reduction of increased or even of normal levels of blood cholesterol. The lowering of blood cholesterol may be achieved by protracted restriction of the intake of cholesterol and of fats. Such dietary approaches have been discussed recently and will not be considered here.

In 1950, the author[1] reported that ultraviolet irradiation of cholesterol and, still more, of powdered egg yolk, decreases their atherogenic effect in rabbits. Following up this observation, eighteen rabbits were given cholesterol orally for three months and were, during this period, irradiated three times weekly with ultraviolet. Depending on the intensity of radiation, the atherosclerotic changes and the rise in serum cholesterol were inhibited in varying degrees.[2]

Applying this experience to humans, seventy-eight patients were treated with ultraviolet light and the levels of serum cholesterol tested before and after irradiation. In a definite majority of cases, the radiation was followed by a marked decrease of serum cholesterol. The number of irradiations did not play a major role, although a relatively strong dose was necessary if only single treatments were given.

As is well known, individual reactions to ultraviolet irradiation vary. Similarly, the influence of ultraviolet irradiation on serum cholesterol showed individual variations.

Method

The irradiations were done in four groups:

Group I: Comprised of twenty-nine cases with vascular diseases who had been hospitalized for a short time. They received single strong ultraviolet irradiations and the serum cholesterol was determined immediately before, two hours after, and twenty-four hours after the treatment.

Group II: Consisting of seventeen ambulant patients, mostly from offices of local physicians, they received irradiations in our laboratory three times week-

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Professor of Anatomy, Department of Anatomy and Laboratory of Gerontology, University of Saskatchewan.
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ly for four weeks, beginning with rather moderate intensities, to each side of the body for one and one-half to two minutes duration, increasing gradually to twenty to twenty-four minutes at 26 inches distance, and using a Burdick Ultra-Lux mercury lamp QA-250 N. These cases were generally in better condition than those of the other three groups.

Group III: Included in this group were sixteen patients, inmates of a mental asylum, mainly chronic and elderly schizophrenics. Thirteen received twelve irradiations in the same way as the patients of the second group, and three cases received only six treatments.

Group IV: Composed of sixteen "chronics," mainly hemiplegics. Twelve cases received one single irradiation and four received six treatments.

In view of the fact that, according to some other workers,[3-5] normal individuals react to ultraviolet irradiation with a rise in serum cholesterol, we also irradiated eight young normal individuals, including one woman in the fifth month of pregnancy. Although this normal series is so far very small (irradiations during the summer were considered unreliable on account of natural insolation and were therefore not done), we cannot confirm the categorical statement of Laurens[6] and others, that normal individuals react to ultraviolet with a rise in serum cholesterol. Our results included rises as well as decreases. The ranges in normal young adults varied from +30 mg. to —26 mg. per cent. Decreases had been reported by Schwalm[6] and by Marcialis.[7]

Results

Regarding the reaction of sick persons to ultraviolet treatment, according to Rost[8] and others, it appears that decrepit patients show little general reaction to ultraviolet. This low response seems to be borne out by the results obtained in our four groups, which seem to be partly linked to the mean age, although some patients over eighty years of age still showed significant reductions of their serum cholesterol after ultraviolet treatment.

The results are summarized in table 1. From this it appears that there may exist a relation between decrease of cholesterol and either age or chronicity of disease, because groups III and IV with higher average of age reacted with lesser reductions. This relation will have to be studied further.

Statistically, the number of cases reacting with a decrease in serum cholesterol is highly significant in group I, significant in II, but not significant in III and IV. If the cases of all four groups are pooled, the result (sixty-one cases of seventy-eight reacting with a decrease of serum cholesterol after ultraviolet irradiations) is highly significant. The mean decrease of 8.9% with S.D. ±15.9, S.E. 1.8, is also highly significant.

For many years it has been maintained

Table 1

Group	No. of cases	No. of cases in which decrease in cholesterol appeared	Average age in years	Mean of serum cholesterol in mg% before | after treatment		*Mean decrease	Standard error	Significance of mean decrease
I	29	26 (=89.6%)	63.8	233	208	10.6%	2.24%	highly significant
II	17	14 (=82.3%)	53.7	238	203	14.2%	4.08%	highly significant
III	16	10 (=62.5%)	68.9	232	217	5.6%	4.4%	not significant
IV	16	11 (=68.75%)	73.5	228	213	5.5%	4.6%	not significant
Four groups combined	78	61 (=78.2%)	64.9	233	210	8.9%	1.8%	highly significant

* Grading in this column was obtained first by determining the difference in percentage for each single case and then taking the mean of these differences.

that ultraviolet irradiation decreases elevated blood pressure and even normal blood pressure, according to Laurens[5] and Hall.[6] In 1934, however, the Council on Physical Therapy* of the American Medical Association,[10] rejected ultraviolet therapy of hypertension because results are inconstant and too slight to be of clinical value. In twenty-four of our cases with hypertension, irradiated twelve times for testing the reaction of serum cholesterol, the reaction of the blood pressure was also followed. In sixteen of them it was lowered at the termination of the treatment. This lowering was not always parallel to a fall in serum cholesterol; in a few patients the pressure decreased even in cases where the serum cholesterol increased. Similarly, subjective symptoms (headaches, dizziness) were ameliorated when the serum cholesterol showed no decrease. Such subjective improvements, following therapy with ultraviolet light, have been reported by others.

Comments

The explanation of the lowering of serum cholesterol by ultraviolet irradiation may be found in an oxidation of cholesterol *in vivo*. It has been maintained by Bedford[11] and others that, like x- and gamma-rays, ultraviolet produce inside the body peroxide and HO radicals which may increase oxidation in the tissues. As far back as 1926, Beumer[12] stated: "The observation that oxycholesterol forms, following ultraviolet irradiation, suggests the influence of light on the skin. Perhaps the same change may be caused by oxidative cell activity." And indeed, Strughold[13] and Raska[14] have invoked failure of respiratory enzymes as the cause of arteriosclerosis. Niacin, which is a co-enzyme of respiratory enzymes, when given to rabbits in relatively high doses (3x0.045 gm. to 3x 0.18 gm.) causes a marked decrease of serum cholesterol.[15] Similar findings were made in humans by Altschul, et al.[16] Furthermore, it is well known that in most cases with hyperthyroidism, the serum cholesterol is low, while in hypothyroidism it is usually increased. This variation may be related to the oxidative action of thyroxin, because according to Dresel,[17] "there is no doubt that thyroxin increases oxidation in tissues, especially in the liver." This oxidative action seems to be the basis of Hueper's[18] statement: "The outstanding therapeutic procedure, apparently capable of preventing the development or arresting the progress of arteriosclerosis of various causation, is represented by a maintenance of an adequate oxygen metabolism. Thyroid and iodine preparations have proved so far to be the most suitable agents, particularly in cases in which an endogenous disturbance of the oxygen metabolism prevails."

Following up the idea of increased oxidation as a means of influencing serum cholesterol and atherogenesis, rabbits were submitted to oxygen inhalation and given daily 0.3 gm. cholesterol by mouth. The increased oxygen inhalation inhibited the arteriosclerosis which otherwise would have developed.[19] In humans with vascular diseases, Altschul and Herman[20] noted that inhalation of oxygen at 40-45 per cent decreased in a majority of cases the serum cholesterol, although here the results were less striking than those obtained by the ultraviolet treatment.

As to the reaction of blood pressure, the most obvious explanation would be the widening of peripheral vessels. The lowering of pressure however lasts, in many cases, longer than the peripheral vasodilatation. For this reason, the author wishes to point to another possible explanation. Although etiologically Volhard[21] finds that cholesterol has "nothing to do" with hypertension, it seems to sensitize the vessel wall for hypertensive substances, mainly adrenalin,[22,23] and subcutaneous injections of adrenalin are said to increase blood cholesterol.[24] Moreover, in hypertensives, the serum cholesterol is often raised,[25,26] and the plasma is said to be supersaturated with cholesterol.[27]

In seventy-eight cases, ultraviolet irra-

*Now Council on Physical Medicine and Rehabilitation.

diation was applied for the purpose of reducing the serum cholesterol. This was achieved in a highly significant number of cases, to a high degree. It appears that the reaction is linked to the reactivity of the individual, depending on (a) constitutional factors, as we know from general reactions of normals to ultraviolet, (b) the age, and (c) perhaps the kind and duration of the disease.

If our cases could have been selected *a priori*, the results, most likely, would be still better. In the four groups, there were only six diabetics, but all of them responded to ultraviolet irradiation with a marked decrease of serum cholesterol. Obviously, the six cases are too small a group to warrant any final statement, but their reaction may suggest a differential approach to the ultraviolet treatment of vascular disorders.

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For reprints, write Dr. Altschul, Department of Anatomy, University of Saskatchewan, Saskatoon, Canada.

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Apparatus for Progressive Resistance Exercise of the Calf Muscles Following Poliomyelitis

Per Bendz, M.D.
Bromma, Sweden

Introduction

Functional incompetence of the triceps surae is a common and distressing sequel to acute poliomyelitis. Heavy demands are made on the strength and flexibility of that muscle during normal ambulation, and even more so in running and/or jumping. A relatively slight impairment of the muscular power abolishes the physiological function and results in a typical limp.

Due to the physiological conditions under which the triceps surae normally functions, problems relative to exercising the incompetent muscle under an adequate load that will neither abolish the function nor provide insufficient stimulus for muscular growth, arise. If strength is to be restored to a weakened muscle, the latter must be exercised in its physiological function against an adequate resistance. The load must not exceed the actual strength of the muscle, so as to make contraction impossible; it must not be less than the strength of the muscle, for the muscle would lack the stimulus for increasing its strength.[2] DeLorme and Watkins, in their pioneer investigations of progressive resistance exercise, demonstrated convincingly the practical significance of rational muscular exercises against adequate resistance.[1-4]

As far as the triceps surae is concerned, its physiological function depends on other factors besides sheer strength, one of which is rhythmic action with rapid alternation between maximum tension and relaxation.

Adhering to the principles of progressive resistance exercise and the special mode of function of the triceps surae, it is not possible to exercise that muscle group rationally by walking exercises or by manual resistance exercises. But with the aid of an apparatus that has been specially designed to exercise the plantar flexion of the foot, it is possible to carry out a rational exercise program.

The primary requisite for apparatus to be used in conjunction with resistance exercise of an isolated muscle group is that its axis of rotation coincides with that of the joint of the relevant extremity, so that the muscle will be properly loaded in every phase of movement.

Description of Apparatus

An apparatus has been designed according to the following principles:

1. A treadle suspended in a frame, on which the foot can be adjusted so that its axis in the talocrural joint coincides with that of the treadle.
2. Dual resistance system:
   a. *Constant* by means of a weight suspended on a chain running over a chain wheel;
   b. *Progressive* by means of a pendulum system having a sliding pendulum weight.

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From the Medical-gymnastic Department of Karolinska Sjukhuset, Stockholm.

3. Calibrated scale on the pendulum arm, enabling the total load to be read directly.
4. Graduated scale for the range of plantar flexion.

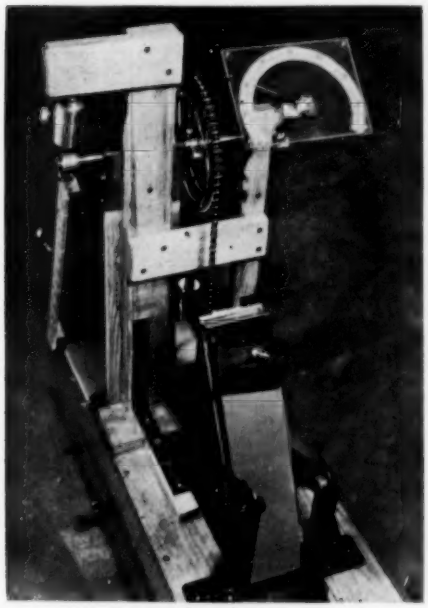

Fig. 1

Comments

Since the axes of rotation of the foot and of the treadle coincide, the triceps surae alone is subject to a load under each phase of plantar flexion (fig. 1).

The foot is kept in position by means of a stop block at the front as well as a heel rest, together with a supporting band over the ankle. The front block rests against the pads of the toes and takes up part of the foot pressure during treadling.

The treadle is readily adjusted to the required initial position by regulating the chain on the chain wheel. The treadle, and the foot itself, should form a slightly acute angle with the lower leg, so that the triceps surae will be extended and receive an initial extensor tone, such as occurs physiologically in walking. This is secured by freely suspending the chain weight so that it lifts the treadle, thereby producing dorsiflexion of the foot and extension of the achilles tendon. From this primary position, the triceps surae can work ideally and bring about approximately 60 degrees of plantar flexion. From the technical standpoint, however, the flexion should be limited to 30-45 degrees.

In exercise of the entire triceps surae, the knee joint should be kept slightly flexed, as in walking. In a separate exercise of the soleus, the knee joint should be flexed to 90 degrees and the treadle adjusted to the horizontal position.

To insure a constant load on the treadle, a series of five weights can be employed: 0.8 kg.; 1.5 kg.; 3 kg.; 5 kg., and 10 kg. The smallest weight just counterbalances the treadle. Since the chain runs on a sector-shaped metal band under the treadle, the load is kept constant regardless of the angle of the treadle. Due to the arrangement of the various levers, the load with plantar flexion is approximately twice the weight employed. For larger feet it will be somewhat less and for smaller feet, somewhat more. The constant load should be so adapted as to amount to at least one-half of the total load.

Pendulum System

With the pendulum weight, it is a simple matter to learn the maximum load the muscle will tolerate. The pendulum system provides a working resistance that increases in proportion to the sinus function of the angle. By using a constant and a progressive load, the maximum can be placed either initially or terminally, and the most apposite proportions can be arranged in each case. In resistance exercises, plantar flexion must aim at the maximal load. The graduated scale, which corresponds to a certain given number of degrees, encourages the patient to achieve that load.

While the scale on the pendulum arm does not give absolute values, it does establish relative ones valid for one and the same person and, in other respects, under constant conditions. It is then possible to obtain a measure of the increase in muscular power as the exercise progresses.

The pendulum system enables rhyth-

mic action to be exercised because the muscle is forced to work against the harmonic oscillation of the pendulum. In this way, the afferent receptors of the muscle receive essential impulses for the automatic regulation of muscular contraction. This regulating mechanism, which has an important bearing on the strength of the muscle, operates during exercise, in the following manner: In the first few exercises, contraction of the triceps surae is uncertain, discontinuous and lacking in force, but as soon as the rhythmic action has been exercised and muscular sensibility has been returned, the muscle continuously contracts with more vigor and considerably greater power.

Discussion

The practical arrangement of a program of exercises should conform to the principles of progressive resistance exercise as formulated by DeLorme and Watkins. However, certain principles especially applicable to the triceps surae should be borne in mind. In the first stage of the exercises, emphasis should be on coordination since this is a prerequisite for increase of muscle strength. The pendulum weight should, therefore, amount to at least one-half of the maximal resistance. Treadling should be performed at a slow rate — approximately 15 strokes per minute. The resistance should be adjusted to 10 R.M. An adequate interval of rest is just as important as the exercise factor. Resistance must be constantly adjusted to the working capacity of the muscle. Separate exercise of the soleus has proved to be of special benefit in many cases, since any weakness of that muscle may be masked by a stronger gastrocnemius and may be detectable only when the knee joint is flexed. The resistance exercises should be supplemented gradually by rhythmic and endurance exercises, as well as increased range of movement, etc. Individual adaptation of the program of exercises must be made with respect to the initial state of the muscle and its reaction to the exercise.

It must be realized that a consistent program of exercises, assiduously carried out, is essential for successful rehabilitation of muscle groups. The apparatus is merely an agent. Other requisites for rational exercise are heating of the muscle prior to exercise, and a warm room to prevent cooling of the heated muscle.

The chances of exercising the triceps surae to a state of functional competence are dependent on the initial state of the muscle and on its potential strength. The apparatus can do no more than help bring about the greatest possible restitution of the muscle. Equipment, using similar principles, has been designed for bed-ridden patients.

For reprints, write Dr. Bendz, Asbacken 4, Bromma, Sweden.

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"Picture-Lessons" in Typewriting for Aphasics

Roy H. Nyquist, M.D.
and
Georgia Crosthwaite, B.S.
Long Beach, Calif.

The Problem

Therapists who treat aphasic patients through the use of typewriting will meet with a special problem, namely, finding meaningful teaching materials. Since an aphasic has to re-learn some lost ability, and often has to be re-trained to speak, read, write, and figure, special treatment is required. This necessitates the use of special materials. Regardless of the purpose of treatment through typewriting, whether it be solely for immediate therapy or for the added purpose of enabling the patient to acquire enough skill for personal use of the machine, the therapist's problem is the same—the finding or devising of suitable teaching materials.

Requirements

To meet the needs of an aphasic patient the teaching material must fulfill three basic requirements. It must, in most cases, be for ONE hand only. The material must contain repetitive drill in unusually large amounts for the slow re-learning process characteristic of aphasia, and in spite of containing much repetitive drill, it should hold the patient's attention and stimulate his interest over a long period of time.

Available Materials

Systems of typewriting for one hand only are numerous. Some have been published by The Southwestern and The H. M. Rowe Publishing Companies. However, most of these systems seem to have been planned primarily for use by persons who, while having lost the use of one hand from amputation or other causes, still retain previous brain function. These methods present too many "reaches" or keys in one lesson. For that reason they lack sufficient drill to fix each key well in mind, and as a result, are particularly unfit for use with aphasics.

Widespread Need

Aphasics with varying degrees of difficulty are found in nearly every hospital. Patients who suffer brain damage from trauma, hemorrhage, thrombosis, or pressure, may have aphasia. Since formal and specialized re-training for aphasia is offered in only a few centers,* rehabilitation of patients who suffer some degree of brain damage presents a challenge to many therapists. In the absence of good teaching materials for aphasics, the suggestion is made that therapists devise the needed lessons.

Devising the Materials

The task of devising materials is not too difficult, even for one who has never made up any kind of lessons for typewriting. What needs to be done is to originate some materials which will contain sufficient repetitive drill, and the most important element, cut-out pictures on each lesson-sheet. The reason for adding pictures to lesson-sheets is obvious. SIGHT is the human sense through which learning takes place most easily. Without question, the task of gathering together all the objects which an aphasic has to re-learn is impossible; using cut-out pictures is a most effective substitute. Pictures are basic in all teaching, and particularly so in the re-training of aphasics. No typewriting materials which illustrate the words presented are available. It is therefore necessary for therapists to make their own.

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From the Paraplegia Service, VA Hospital and Department of Physical Medicine, School of Medicine, University of Southern California.
From the Educational Therapy Section, Physical Medicine Rehabilitation Service, VA Hospital.

* V. A. Aphasia Centers: Framingham, Massachusetts, Minneapolis, Minnesota, Long Beach, California, and St. Louis, Missouri.
Some other centers: Speech Clinic, University of Michigan, Ann Arbor, Speech Department, University of Chicago, and Speech Department, University of Southern California, Los Angeles.

Two Questions

The first question which arises is: Which keyboard to use, the standard or the Dvorak? Both have their advantages. On the Dvorak keyboards, for either the right or left hand, the most-used keys are arranged for striking with the strongest fingers. As a result, the patient can learn to type with greater ease and speed. However, one who learns the Dvorak system cannot without retraining, use a standard machine. On the other hand, the standard keyboard demands many long and difficult reaches to much-used keys, so that acquiring any speed whatsoever takes longer. However, it has the important advantage of being available wherever typewriters are used. For this reason the use of the standard keyboard is presented (fig. 1, 2, 3).

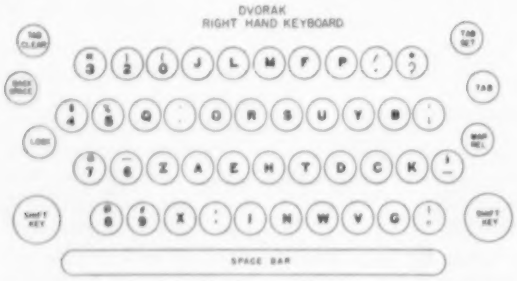

Fig. 1 — Dvorak right hand keyboard — chief advantage is in amputation of the left arm; chief disadvantage is that it is usually not readily available.

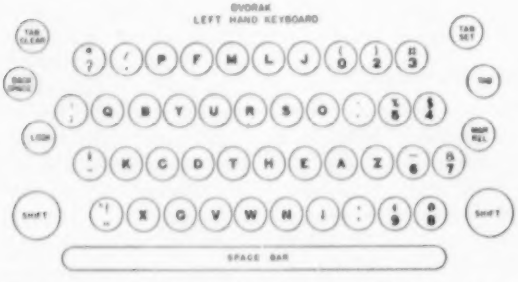

Fig. 2 — Dvorak left hand keyboard — chief advantage is in amputation of the right arm; chief disadvantage is that it is usually not readily available.

The next question is: What keys to use as the "home-row?" The keys most often chosen are FGHJ, for either the right or left hand. Reasons for selecting FGHJ are 1) the keys are compactly situated; 2) they are in the center of the keyboard; 3) the hand rests comfortably on them, and 4) the position of the hand on these four keys lends itself to TOUCH typing (fig. 4).

Suggested Steps

The first step after having chosen FGHJ for the home-row is to *plan the entire sequence* of presenting the rest of the keys. As each key or letter is added to the planned sequence, a list of words which can then be spelled should be compiled. As nearly as possible, confine the list to common words. Preparation of lists of the words to be used and illustrated should be done *before* searching for pictures. The therapist will then know in advance what pictures are needed or can be used.

The next step is to search through magazines for suitable pictures to illustrate words in the prepared lists. After

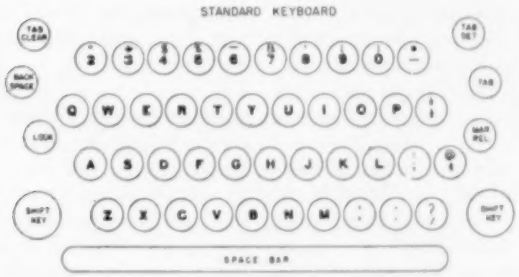

Fig. 3 — Standard keyboard — chief advantage is that it is usually readily available.

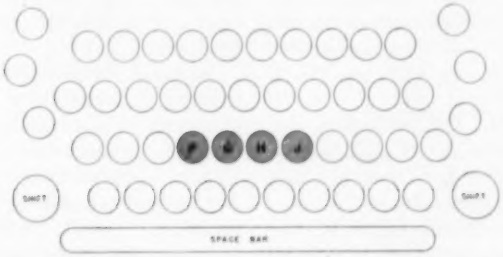

Fig. 4 — The starting point or "home-row" on the standard keyboard.

pictures have been found, material to accompany the pictures should be prepared. Since no words can be spelled with the four home-row consonants, FGHJ, the first lesson-sheet can be nothing more than several lines of drill devoted solely to the teaching of these four keys. Later, when the therapist actually uses these lines of drill in treatment, adjustment may have to be made to coincide with the learning ability of individual patients. If the patient learns quickly, he will soon be able to follow the letter-combinations in the drill after only a few minutes of introductory dictation. Many patients, however, will have difficulty in following the groups of letters which spell nothing, and the therapist must continue to dictate sufficient repetition.

On this first lesson-sheet a vowel should be introduced as well, so that complete words may be typed. The choice of which vowel to present first is purely arbitrary. If E is chosen, the two-letter word "he" can be offered immediately. A picture of a man or other male is added to the lesson-sheet, with some drill on the "reach" of EF, plus a simple statement about what "he" in the picture is doing. Read the statement slowly to the patient, pointing to each word as it is said, but do not permit him to type more than the one word "he." To avoid the patient's trying to type all the words in the statement, try typing in another color the words which should not be attempted at this early stage. Another common word which can be typed with E and the home-row keys is "egg"—a very desirable word to be illustrated (fig. 5).

A good letter to present next is U, since the key will be depressed by a finger at the opposite side of the hand from E. The drill material can be illustrated by pictures of "jug" and "hug." The latter word, with an appropriate illustration, will add zest to remembering the word.

By presenting R next, the word "her" may be illustrated by a picture of a girl or other female. "Fur" and "rug" are good concrete objects for illustration. "Referee" is another word which may be used, depending on its significance

for the individual patient. The words "here" and "free" are also possible. However, these two words are concepts and not objects which can be seen. Attention should be given to objects alone at first.

The letter T may be presented next, with easy to illustrate words such as "tree, feet, teeth, three, and hurt." Although "three" and "hurt" are really concepts, they can be easily pictured in connection with "feet, teeth," or other words previously introduced.

Using Y as the next letter, along with an unobtrusive and informal introduction of S, some of the more common words now possible are "eyes, see, three, trees, she, sheets," etc.

Up to this point the home-row, the four keys just above, as well as E and S, have been introduced. There are advantages in presenting the keys in this sequence. The five keys, ERTYU, are close to the hand, and the "reach" to them is easy to make without moving the hand off the home-row position. If the therapist wants to train the patient to type even partly by touch, long reaches should not be presented at first.

Following the above ten keys, another easy reach and a very useful letter is I. Such words as "I, tie, tire, fire, fight, fish, shirt," etc., are easily illustrated and common enough to make their inclusion worthwhile. The letter A should be taught just enough to permit the patient to use it as an article before phrases such as "a tire," "a fish," or "a shirt." Use of the period and the shift-lock key for capital letters should be introduced at this time. These two keys may not require separate lesson-sheets, and their use enables the patient to type short but complete statements, such as "I see a tire" (fig. 6).

At this point, the choice of which key or letter to present next is not as vitally important as it was in the beginning. If a patient learns easily, two new letters or keys may sometimes be presented on one lesson-sheet, especially if the two are needed to type the word illustrated. For example, D and O may be offered at the same time, since the reaches to these two keys are to opposite sides of the keyboard. It will be easy to find cut-out pictures of "dog, hog, red, dress," etc. Soon the therapist will have presented

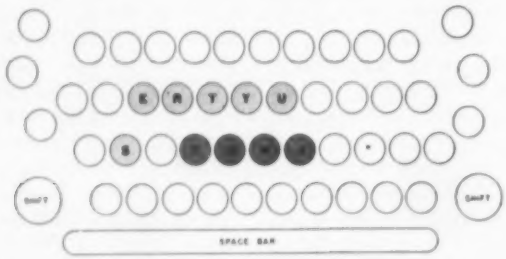

Fig. 5 — Illustrates one method of adding additional keys to those already mastered on the standard keyboard.

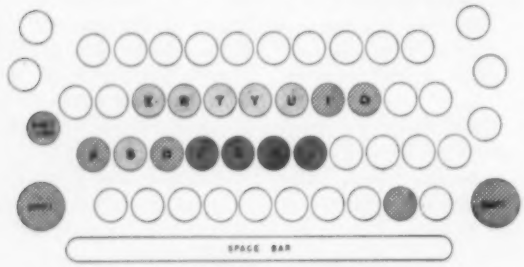

Fig. 6 — Illustrates one method of selecting the remaining keys on the standard keyboard.

enough letters to provide longer lists of a wider variety of words.

Cautions

Although the sequence grows gradually less important, there are some pitfalls to avoid in presenting the remaining keys. For example, always select a new key to be presented which is as widely separated as possible on the keyboard from the key just previously presented. Avoid offering two keys side by side in successive lesson-sheets, if both keys are to be depressed by the same finger. This means that the many keys to be depressed by the index and little fingers should be judiciously scattered.

Selection of good pictures for the lesson-sheets is important. A "good" picture is one which gives prominence to the object or idea for which it is used. The picture should contain few details, and especially none that detract from the object which illustrates the word being taught. A good picture should be brightly colored. Avoid black and white combinations, unless they are of bold and simple design. The following suggestions should be kept in mind when selecting pictures: 1) For interest, choose action-pictures of people or animals, or both; 2) for eye-appeal, trim them along geometric rather than rectangular lines; 3) when possible, choose pictures composed of the primary colors—yellow, red, and blue, since these three colors, plus the secondary colors of green, violet, and orange, may be used to teach color-words; 4) besides choosing pictures which have strong human interest, find some that are humorous—laughter helps learning, and 5) try to locate some pictures of things which remind the patient of his own previous experiences and background since they will please him and will create an emotional tone that will deepen his retention.

Keep materials fresh. Do not allow any set of picture-lesson-sheets to become fixed or stale. Pictures become dated. Individual patients require varying amounts of drill and different pictures. After completing one set, keep up the search for new and more interesting illustrations. Re-work the lesson-sheets to suit the drill for each patient, so that none will become discouraged or disinterested. By having many lesson-sheets available for teaching each letter or "reach," the therapist can use those pictures which have most appeal to each patient. A patient likes to be shown several picture-sheets and allowed to choose the ones he prefers. Keep the lessons flexible, vital, and ever-growing. This device would lose its spontaneity and much of its effectiveness if the materials were ever published in standard book form.

Treatment Methods

Although the manner in which the therapist presents materials contained in a set of picture-lessons may vary with individual patient ability and needs, the following hints may be helpful: 1) Show the patient the picture without the typed drill. He may be able to respond with the desired principal word or perhaps with some other words. At any rate, he should be given opportunity to try; 2) after the patient has looked at the picture and possibly spoken some words by himself, the illustration is then clipped onto the lesson-sheet and any new reach involved is presented orally. Urge the patient to call the new letter as he strikes the key, and repeat the action many times. Then have him call each letter in the new word as he strikes the keys. The word should be pronounced each time after it is spelled. If the patient cannot call the letters of the alphabet or pronounce words without help, have him drill with the therapist. Then, if the therapist cannot give further individual attention, the patient may type alone. When he has finished the practice material, he is asked to repeat the new word again and type it once more, spelling it as he does so. Verbalization must be emphasized in this treatment, even in a hospital where there is an Aphasia Clinic.

Assembling the Materials

The simplest method is to attach the cut-out pictures to sheets of typing paper, and keep the sheets in a manila folder. *Note* that in the drill on the "reaches," the words and phrases, and the short statements must be typed on the sheets before the pictures are attached. This typed material should be spaced on the sheet according to the size and shape of the picture used. The means of attaching the pictures to the sheets of paper can be a matter of choice.

Such a casual device has definite advantages. It is possible to detach and show a picture to the patient without the typed words. It permits easy transfer of pictures from one sheet to another as desired for use with varying amounts of drill.

Evaluation

The effectiveness of the use of this method or device can be evaluated only in generalized terms. In our experience the method has been found much more effective than other methods which do not make use of pictures. Without pictures, the materials used before had little meaning to the patient. Typing without visual aids was a routine task performed with little or no understanding of the meaning of the typed words. There was also a corresponding lack of interest. Aphasic patients who have been treated by the use of these picture-lessons not only have learned to use the keyboard much faster, they also have a better retention of letters and words.

Summary

The published materials available for teaching typewriting to persons with one usable hand are not adequate for the treatment of aphasia. Any therapist treating aphasics can and should expand and improve such materials. Lessons so devised will be more effective if they are organized around cut-out pictures of common objects and experiences. The idea offered here is simple—it is merely adding *sight* to teaching materials.

Effective material for teaching typewriting to aphasics must be suitable for one hand, contain sufficient repetition compatible with slow re-learning, be capable of holding attention, and stimulate interest in spite of repetition. A flexible method for devising such material for the standard keyboard has been presented. A method of learning the keyboard, very gradually, has been described. In devising the material, steps are given in the selection of the sequence of keys, selection of words, and selection of good illustrations. This method adds pictures to the words used in the lessons. Verbalization has also been emphasized. Using good pictures with the words adds a correlated mental object picture to the mental key or letter picture and to the mental word picture, helps stimulate the patient's interest in the lesson, helps the patient learn to use the keyboard much faster, and helps the patient to remember the letters and words better.

Acknowledgement — The authors gratefully acknowledge the assistance of the Medical Illustration Department in the preparation of the photographs used in this study.

For reprints, write Dr. Nyquist, Chief, Physical Medicine Section Paraplegia Service, VA Hospital, Long Beach 4, Calif.

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MEDICAL NEWS

Members are invited to send to this office items of news of general interest, for example, those relating to society activities, new hospitals, education, etc. Programs should be received at least six weeks before the date of meeting.

Dr. Zeiter Receives New Appointment

Due to the resignation of Clarence M. Taylor as executive director of The Cleveland Clinic Foundation, Dr. Walter J. Zeiter has been appointed medical co-ordinator, with the responsibility of co-ordinating medical and surgical services with the administrative departments.

Personals

The 51st Annual Congress on Medical Education and Licensure of the American Medical Association, held at the Palmer House in Chicago on February 5, was attended by the following Congress members: **Robert L. Bennett; Harold Dinken; Earl C. Elkins; Frank H. Krusen; William D. Paul; Wm. Benham Snow** and **Walter J. Zeiter.** — Doctors Krusen and **H. F. Polley** were representatives of the Mayo Clinic staff who attended the interim meeting of the AMA in Miami. — At the annual meeting of the Iowa State Medical Society, held in April at Des Moines, William D. Paul presented the scientific exhibit "Physical Therapy in Dermatology." — **Theodore Stonehill** of Los Angeles was a member of a panel on "Low Back and Leg Pain" at a staff meeting of Culver City Hospital held in March. — On March 17, Cedars of Lebanon Hospital held a Medical Clinical Pathological Conference. The topic "Rehabilitation of the Cervical Disc Case" was presented by **John H. Aldes** of Los Angeles. — **Edwin C. Welsh,** Milwaukee, spoke on "Experience with Amino Acids and Exercise in the Treatment of Muscular Dystrophy in a Boy: A Case History" at the conference on optimal nutrition, its analysis and application, held at George Williams College in Chicago in April. **Ben L. Boynton** of Chicago also participated by presenting "Some Unexpected Results from Rehabilitation Procedures Supported by a Program of Optimal Nutrition." Dr. Boynton gave a talk on "Principles of Rehabilitation" at the annual meeting of American Association of Railway Surgeons, held in Chicago at the Drake Hotel, April 12-14. — The National Rehabilitation Association has the following representatives who are Congress members: **Josephine Buchanan** is a board member in the District of Columbia; **Gerald G. Hirschberg** is president of the East Bay (California) group and **Leonard J. Yamshon** is first vice-president of the Southern California group. — **Michael M. Dacso,** New York City, has been appointed consultant in physical medicine and rehabilitation at St. Barnabas Hospital, New York City. — At the third annual scientific assembly of the West Virginia Academy of General Practice held in April, **Edward W. Lowman,** New York City, presented the topic "Chronic Rheumatoid Arthritic: Total Rehabilitation." — The Iowa Academy of General Practice held a symposium on diseases of the heart in Des Moines on May 19. **Joseph G. Benton** of New York City spoke on "Rehabilitation of the Patient with Cardiovascular Disease — An Increasing Community Responsibility." Dr. Benton was very active at the annual meeting of the State Medical Society of Wisconsin in May — he presented the subject "Rehabilitation of the Patient with Cardiovascular Disease" and was a member of the panel discussing the topic "Can Cardiacs Work?" — **Theodore H. Coffey,** London, Ont., Canada, participated in the annual convention of the Medical Society of the State of New York, Buffalo, May 9-13, by presenting "Pitfalls in Treatment of Athletic Injuries." — The Food Law Institute, Inc., New York City, will meet on June 30, 1956. The following have been appointed by the president of the Congress to represent us: **Emil J. Hildenbrand** and **Isadore Levin,** both of Washington, D. C. — **Karl Harpuder,** New York City, was guest speaker at the luncheon of the section of physical medicine at the annual meeting of the Massachusetts Medical Society, held in Boston, Hotel Statler, May 17-19. He chose the following topic "Rehabilitation of the Patient with Arterial Disease of the Limbs." — The newly organized Kansas Chapter of the National Multiple Sclerosis Society has appointed **Donald L. Rose,** Kansas City, Kansas, to serve as medical advisor. — **S. Malvern Dorinson,** San Francisco, recently spoke at pediatric grand rounds of

Childrens Hospital on "Orthopedic Aspects in Cerebral Palsy." Dr. Dorinson also addressed the orthopedic staff at Mt. Zion Hospital on "Uses of Ultrasound" and the obstetrical staff on "Physical Medicine in Obstetrics and Gynecology." — Jefferson Medical College in Philadelphia has recently promoted **Herman L. Rudolph** of Reading, Pennsylvania, to assistant professor of physical medicine. — **Frederic J. Kottke** of Minneapolis is serving on the American Board of Physical Medicine and Rehabilitation as a representative of the American Society of PM&R. — At the meeting of the Mid-Eastern Chapter of the American Association of Rehabilitation Therapists, Richmond, Virginia, **A. Ray Dawson** addressed the group on "The Broadening Trends in the Field of Rehabilitation." — **Earl F. Hoerner**, West Orange, N. J., has been appointed chairman of a committee on "Total Rehabilitation" under the New Jersey Welfare Council. Dr. Hoerner participated in a meeting of Administrative Advisory Committee to Sheltered Workshops held on May 20. — The Medical Society of the State of Pennsylvania has a standing committee on "Disease Control." **Albert A. Martucci** of Abington is a member of this committee representing the field of PM&R.

Chicago Society of PM&R Elections

The Chicago Society of Physical Medicine and Rehabilitation, at its April meeting, elected the following officers for the year 1955-1956: Joseph Koczur, President; Gusta Davidsohn, Vice President and chairman of the Program Committee; Ralph E. De Forest, Secretary-Treasurer.

In Memoriam

Dr. Edward A. Klauber, 55, of Staten Island, New York, died May 1, 1954. Death was due to a heart attack. Dr. Klauber was a Congress member for many years. He served during World War II; and was later affiliated with Richmond Borough Hospital and the Staten Island Hospital.

Correction

In the April issue of the ARCHIVES, it was printed that Lee B. Greene of Bridgeport, Conn., is attending consultant in Physical Medicine and Rehabilitation at the West Haven VA Hospital. This information should read that Dr. Greene is attending, West Haven VA Hospital. Our apologies to Dr. Greene.

Latin American Congress Meets In New York

The Latin American Congress of Physical Medicine held its annual dinner on Wednesday, April 20, New York City. Hosted were the Pan-American Academy of General Practice and the Spanish American Medical Association of New York. On the dinner committee were Doctors Madge C. L. McGuinness and Jerome Weiss.

William Bierman Honored at Dinner

The New York Society of Physical Medicine and Rehabilitation celebrated its 34th anniversary by honoring William Bierman at dinner on Wednesday, April 27, New York City. Dr. Bierman was presented with a medal as shown below. An exact copy of this medal, modeled by the internationally reknowned sculptor, Mr. Cecil Howard, may be purchased from Physical Medicine Medals, 360 Fountain St., New Haven, Conn.

Congress Participates at AMA Meeting

The AMA Section on Physical Medicine and Rehabilitation met in Atlantic City early this month. The following papers were presented: "The Importance of Diagnostic Procedures in Physical Medicine — Chairman's Address" by William H. Schmidt; "Current Trends in Physical Medicine and Rehabilitation" by Arthur L. Watkins; "Treatment of the Patient with Rheumatoid Arthritis by Physical Means" by James W. Rae, Jr.; "Further Evaluation of Heating by Microwaves and by Infrared as Used Clinically" by Gordon Martin and Julia Herrick; "Common Causes of Pain in the Neck and Shoulder and Their Response to Therapy" by Edward M. Krusen; "Role of Inactivity in Production of Disease: Hypokinetic Disease" by Hans Kraus and co-authors; "Mobile Physical Therapy Unit for Treatment of Arthritis" by Thomas F. Hines; "The Role of Occupational Therapy in Rehabilitation" by Robert L. Bennett; "Mobilization of the Helpless Patient: A Case Presentation" by Herman L. Rudolph; "Electromyography as an Aid in Medical Diagnosis" by Paul A. Shea and co-author; "The Use of Ultrasonic Radiation in the Treatment of Epicondylitis" by John H. Aldes; "Placement of Rehabilitated Patients" by A. Ray Dawson and co-author; "Preliminary Experience with Exoskeletal Splithook Prostheses for Upper Extremities of Traumatic Quadriplegic Patients" by Roy Nyquist. These papers were discussed by Frank H. Krusen, Edward W. Lowman, Bruce B. Grynbaum, Richard T. Smith, Harold Dinken, Ralph E. Worden, Louis B. Newman, Walter J. Treanor, O. Leonard Huddleston, William Bierman, Ben L. Boynton and John H. Kuitert.

Scientific exhibits presented were: "What Is Osteoarthritis?" by William H. Georgi, et al; "Anatomical Studies of the Joints" by Arthur M. Pruce, et al; "Physical Medicine in the Treatment of Arthritis" by Edward W. Lowman; "Blood Volume Determinations for Anesthesia" by Otto Glasser; "Gout and Probenecid" by Richard T. Smith; "Rapid Alveolar Carbon Dioxide Analysis—An Aid to the Diagnosis of Ventilatory Abnormalities" by Clarence W. Dail, et al; "Evaluation and Treatment: Secondary Changes in Knee Dysfunction in Geriatric Patients" by Keith C. Keeler; "Ambulation of the Elderly Amputee" by Harold Dinken, et al; "The Rehabilitation of Children with Muscular Dystrophy, Spina Bifida, and Amputations" by G. G. Deaver; "Operation of the Prosthetic Team in a Rehabilitation Center" by O. Leonard Huddleston, Sedgwick Mead, et al; "Hypokinetic Disease" by Hans Kraus, et al; "Rehabilitation of the Severely Disabled: Medical and Vocational Follow-Up" by Morton Hoberman, et al; "Clinical Hydrotherapy" by Hans J. Behrend and Jerome Weiss; "Exercise and Peripheral and Visceral Blood Flow" by Karl Harpuder and Irwin D. Stein; "Restitution of Function Following Hemiplegia" by Walter J. Treanor, Raoul C. Psaki, et al; "Lower Extremity: Temporary Training Prostheses (Pylon)" by Maxwell D. Flank, Erma A. Smith, et al; "Classification of Early Lateral Deviations of Spine Following Poliomyelitis" by Robert L. Bennett, and "Partial Gastrectomy With or Without Vagus Resection for Duodenal or Marginal Ulcer" by Bernard J. Doyle, et al.

The following acted as consultants in the field and were on duty to advise and answer questions: Robert L. Bennett, Arthur L. Watkins, Keith C. Keeler and A. Ray Dawson.

Books Received

Books received are acknowledged in this column as full return for the courtesy of the senders. Reviews will be published in future issues of the journal. Books listed are not available for lending.

Cardiac Injury Resulting from Effort of Trauma: Clinical and Legal Aspects by Ernst P. Boas: Edwards Brothers, Inc., Ann Arbor, Mich.

Of Publishing Scientific Papers by George E. Burch: Grune & Stratton, Inc., New York City.

Handbook of Treatment by Harold T. Hyman: J. B. Lippincott Co., Philadelphia.

Leaves From A Doctor's Diary by Edith E. Johnson: Pacific Books, Palo Alto, Calif.

Cardiac Emergencies and Heart Failure—Prevention and Treatment by Arthur M. Master, et al: Lea & Febiger, Philadelphia.

The Human Brain by John Pfeiffer: Harper Bros., New York City.

Sports Injuries by Christopher Woodard: Track & Field News, Los Altos, Calif.

Radiobiology Symposium 1954: Proceedings of the Symposium Held at Liege, 1954 edited by Z. M. Bacq, and Peter Alexander: Academic Press, Inc., New York City.

Canadian Cancer Conference, Volume I, Proceedings of the First Canadian Cancer Research Conference, Honey Harbour, Ontario, June 16-19, 1954 edited by R. W. Begg, Academic Press, Inc., New York City.

The Clinical Interview, Volume II by Felix Deutsch, and William F. Murphy: International Universities Press, New York City.

Science and Man's Hope by James S. Fulton: Bookman Associates, New York City.

Pulmonary Diseases edited by Roscoe L. Pullen: Lea & Febiger, Philadelphia.

Annual Review of Medicine edited by David A. Rytand, and John Anderson: Annual Reviews, Inc., Stanford, Calif.

PHYSICAL MEDICINE ABSTRACTS

The Effect of Sex Hormone Administration on the Calcium and Nitrogen Balance in Elderly Women. P. G. Ackermann, et al. J. Gerontol. 9:450 (Oct.) 1954.

The authors found that nutritional requirements of elderly individuals may differ from those of young adults. Elderly subjects require a larger intake of protein and calcium for balance than do younger persons. It was also found that in elderly men the administration of testosterone produced a positive nitrogen balance. Other work has indicated that the administration of estrogens and androgens to elderly women had a favorable effect on their clinical and mental status. The effect of hormone therapy on calcium and nitrogen balance in seven elderly female subjects is reported.

Estrogen administered in amounts sufficient to reinduce menstruation in elderly subjects caused little effect on the calcium balance. Likewise, there was no effect on the nitrogen balance in any of the subjects, who were initially in positive balance.

Large doses of testosterone produced a marked increase in nitrogen and calcium retention; similar doses of progesterone had less effect.

The Fate of Femora with Pathologic Fractures Stabilized by Intramedullary Nails. John Lyford III. Radiology 64:197 (Feb.) 1955.

Femoral stabilization of pathologic fractures by use of intramedullary nails offers a valuable adjunct in the management of these difficult cases. The author reports two such cases, one had metastatic carcinoma and the other osteogenic sarcoma. They were followed over a period of months, having had serial roentgenograms. Amputation had been refused by both patients.

The author believes that the benefits of the procedure outweighed any possible untoward results. In each instance, the patient remained mobile and relatively free from pain in the involved extremities. Death occurred about eight months after the fracture. The serial roentgenograms showed progressive replacement of the shaft of the involved femur by the tumor. This would indicate that the tumor replacing the bone was sufficiently "firm" to permit stabilization by the intramedullary rods. The tumor, as it spread, appeared to grow particularly around the rod.

Present Trends in the Management of Cleft Lip and Cleft Palate. Robert H. Ivy. West J. Surg. 63:60 (Feb.) 1955.

Cleft lip and cleft palate are, second only to clubfoot, among the commonest congenital anomalies. This deformity causes defective speech, unsightly facial appearance, dental malocclusion, and social maladjustment. Those subjected to it are apt to be regarded as cripples, just as much as those who suffer from disabilities resulting from poliomyelitis or cerebral palsy. The child with a cleft palate may seem to be slow to learn, but this is usually the result of having poor speech and in many cases defective hearing, as well as sensitiveness about appearance. The possibility of complete rehabilitation of individuals who have cleft lip and palate is generally much greater than that of persons who have had poliomyelitis or cerebral palsy.

The entire problem should be explained to parents when the child is very young. An outline of treatment which may be necessary over a period of several years should be described, and it should be emphasized that the outlook is optimistic. The parents should be put in a frame of mind to accept the condition and cooperate fully in the rehabilitation.

Surgical closure of cleft lip is best achieved by waiting until a child is six weeks to three months old, or has reached ten pounds in weight, and is otherwise in good physical condition. The decision to perform surgery and the management of a major cleft of the palate requires not only the services of a plastic surgeon, but the careful consultation of the pediatrician, the otolaryngologist, dental specialists, the psychologist, and the speech therapist. All of these should work together as a team.

Surgery involving only the soft palate may be done at about two years of age, but when it is necessary to expose bone, it is best to postpone the surgery until the child is at least four years of age.

The Medical Management of Rheumatoid Arthritis. H. G. Kelly. Canad. M.A.J. 72:283 (Feb.) 1955.

In reviewing the medical management of

rheumatoid arthritis, the author points out that cortisone acts on tissues purely as an anti-inflammatory agent and does not correct the underlying and still unknown metabolic cause of the disease. He emphasizes the great variation in the natural course of the disease. About 50 per cent of any large group of patients can be expected to have a complete remission of symptoms or a mild course featured by recurring pain and swelling in the joints. The other 50 per cent develop joint deformities, sometimes to a degree which confines them to bed or wheelchair, despite the best of care.

To have the patient in the hospital for a short period of study when the diagnosis of rheumatoid arthritis is first made has several uses. Accurate assessment of the severity of the systemic reaction aids in determining the prognosis. The response to correct conservative management can be determined, and the patient can be given a clearer concept of his problem and what to do about it.

Cortisone should not be given in doses of 200 to 300 milligrams a day because of the complications of hypercortisonism. The aim should be to use the smallest daily dose needed to control symptoms. Derivatives of salicylic acid exert an anti-inflammatory action in the tissue when used in collagen disease and are of considerable value in treatment of rheumatoid arthritis. Rest and relaxation are still most likely to hasten remission. Exercise is important to preserve and restore muscle power and prevent joint deformities.

The Cross-Eyed Child. A. E. Braley, and H. M. Burian. J. Iowa Med. Soc. **XLV**:185 (April) 1955.

If misalignment of the eyes is allowed to persist, it may not only cause severe psychologic trauma, but may become impossible to treat. It is no longer necessary to wait until the child is old enough to become conscious of the defect. No child is too young to have treatment for a neuromuscular anomaly of the eyes.

There may be various causes for deviation of the visual lines in a young child. Paralysis of one or more of the extraocular muscles is rarely a cause of strabismus. Mechanical anomalies of orbital shape, and muscle or tendon attachments are also of minor importance. The innervational factors play the most important role in the etiology of the so-called comitant deviations. The best-known factors are those concerned with the functions of convergence and divergence.

A strong tonic convergence impulse is present in all young children and in time, it gradually decreases in power. This is one of the reasons why acquired strabismus in a child is usually convergent, whereas it is divergent in the adult. Another important component of the convergence function is the so-called accommodative convergence. To fixate an object at close range, a person who is farsighted without corrective lenses must make a greater accommodative effort than does an emmetropic person, and excessive convergence results. In contrast, an uncorrected myope requires less accommodation and his convergence will be insufficiently stimulated. Such excessive or deficient accommodative convergence can be shown to exist in a very large number of squinting children. In addition to these relatively simple innervational causative factors, more deepseated and widespread disturbances of the central nervous system may be the ultimate cause of squint.

Whatever the ultimate cause may be, a manifest, obvious misalignment of the visual axes will not appear unless there is a disturbance of the so-called fusion mechanism, which keeps the eyes properly aligned. Many minor degrees of misalignment are kept in check by the fusion mechanism. In the last analysis, then, a comitant strabismus is the result of an imbalance between the forces which tend to keep the eyes aligned and the forces which tend to produce a deviation.

The therapy of comitant strabismus is both nonsurgical and surgical. The attempt in every case is not only to achieve a cosmetic but also a functional result. More attention is being given to obtaining good vision in each eye and proper binocular cooperation before the child is operated upon. The development of normal binocular vision can be assisted by postoperative nonsurgical treatment.

Nonsurgical treatment in the small child consists essentially of the prescription of spectacles and of occlusion treatment (the wearing of a patch over one eye). Somewhat later, more active therapy is used, consisting first of home exercises to obtain good fixation and normal vision in each eye. Then orthoptic training is usually added. These exercises, given both at home and the office, aim at combatting suppression and at re-educating the patient to use binocular vision.

BOOK REVIEWS

The reviews here published have been prepared by competent authorities and do not necessarily represent the opinions of the American Congress of Physical Medicine and Rehabilitation and/or the American Society of Physical Medicine and Rehabilitation.

TRUE ADVENTURES OF DOCTORS. By Rhoda Truax. Cloth. Price, $2.75. Pp. 216, with illustrations. Little, Brown & Company, 34 Beacon St., Boston 6, 1954.

Physicians are prone to discount the importance of their work, and to lose sight of the romance of medical discoveries in their preoccupation with technicalities. Rhoda Truax has found adventure in the discoveries of men of medicine from the times of Ambroise Pare to those of Fleming, Blalock and Taussig. She has succeeded in conveying to the young lay reader the thrills of Andreas Vesalius in his dissections—to do this he risked imprisonment to secure bodies for study. In the disclosure of facts that differed from ideas of Galen, the hallowed authority, young Andreas risked ostracism, and even excommunication. Leopold Auenbrugger and Rene Laennec are made to seem actual characters, puzzling over the problems of how to find out what is happening inside the chest by tapping and listening to the tones, or by placing the ear to a simple roll of paper made into the first crude stethoscope. Pinel, Lister, Ehllich, Minot and Drew live again through the skilled though brief word pictures which the author draws of these famous men of medicine.

Who knows but that some genius of years to come may be inspired by these stories to similar accomplishments in the healing art? This book is a fitting gift for any younger reader, and should find a place in many school libraries.

HUMAN BIOCHEMISTRY. By Israel S. Kleiner, Ph.D. Fourth edition. Cloth. Price, $7.50. Pp. 746, with 93 illustrations and 5 color plates. The C. V. Mosby Company, 3207 Washington Blvd., St. Louis 3, 1954.

This compact biochemistry text is well proportioned to the needs of medical students and the reference requirements of physicians. In its present form it is representative of several similar texts, all of which aim at better correlation of biochemistry and clinical medicine. The first edition (1945) was a precursor in this mode of presentation. The present edition incorporates new information with little increase in bulk over the third edition. It is an admirable, relatively inexpensive source of information in a rapidly expanding field.

A TRANSLATION OF LUIGI GALVANI'S DE VIRIBUS ELECTRICITATIS IN MOTU MUSCULARI COMMENTARIUS. COMMENTARY ON THE EFFECT OF ELECTRICITY ON MUSCULAR MOTION. By Robert Montraville Green, M.D. Cloth. Price, $4.00. Pp. 97, with 4 illustrations. Elizabeth Licht, Publisher, 30 Hillside Ave., Cambridge 40, Mass., 1953.

In this excellent translation of Galvani's Commentary on the Effect of Electricity on Muscular Motion, one is very much impressed by the scientific approach used by Galvani to present his theories. Though this was published in 1791, the thoroughness of his investigations and the way they were related could be contemporary. His contribution in the field of Electricity and Electrophysiology is a model of work that could be an example of scientific reasoning in other fields.

Galvani attributed his discoveries and findings partly to "chance and fortune and partly to his own diligence and industry." The integrity, cautiousness and thoroughness of his work reveals the mind of a true scientist. It is quite understandable that his discoveries had such a great influence in the scientific world, even upon those who did not agree with him.

He made his first experiment on animal electricity in 1780, but waited eleven years before publishing his results on excitability of the nervous system in frogs. He compared a muscle fiber to a small Leyden jar charged with two opposite kinds of electricity, — the nerve being the conductor. Divergence of opinion between Galvani and Volta gave way to numerous experiments and arguments which resulted in new discoveries. One of these was a demonstration of polarization potential of muscle. Galvani showed that muscular contraction could be elicited in frogs without the use of metals. This theory brought Volta to discover the "Voltaic pile." Galvani described the phenomenon of inhibition which is particularly important in physiology and psychology.

In his book he postulates that there are two kinds of electricity, one positive and one negative and when there is equilibrium between the two, there is no phenomenon of muscular contraction. He was rather inclined to believe that both kinds of electricity were located in

muscle. He labels the phenomenon under the general heading, "Animal Electricity". He stated that Animal Electricity had some similarity with artificial or ordinary electricity. Galvani studied both normal and pathological contraction of muscles and also their reaction to external electricity.

This book is highly recommended to those who are interested in the history of electrophysiology. It gives an insight into the problems which Galvani had to overcome. It describes beautifully methods and reasonings which were used to establish his theories. The clarity and freshness of the author's approach is reflected in this translation.

TWO LEGS TO STAND ON. By John D. McKee. Cloth. Price, $2.75. Pp. 180. Appleton-Century-Crofts, Inc., 35 W. 32nd St., New York 1, 1955.

This is the story of the great courage which a boy, afflicted with cerebral palsy, received from his parents. The author describes his development from a severely involved child through therapy, surgery, school, extra-curricula activities, and finally to a reporter's position.

While necessarily subjective in approach, the attitude is realistic and makes no attempt at tear jerking. The role which the parents played is emphasized.

This book should be read by all teen-agers with handicaps regardless of type, and by parents of cerebral palsied children who are amenable to treatment.

AMPUTATIONS. By Leon Gillis, M.B.E. Cloth. Price, $12.75. Pp. 423, with illustrations. Grune & Stratton, Inc., 381 Fourth Ave., New York 16, 1954.

This eminent British surgeon has written a classic comprehensive text-book based on his experience and those of his colleagues. The Roehampton amputation center in England has pioneered in amputation technics and prostheses. In this book, Mr. Gillis stresses, quite wisely, the standard types of surgical procedures which have weathered the test of time. Nevertheless, he finds time to question other technics and suggests important changes in the light of the more modern and advanced prostheses which now are available. The problem of vascular diseases is considered at some length. If the blood flow to the affected limb can be increased, amputation may be avoided or the level of elective surgery influenced. The chapters on congenital anomalies, short limb management, and amputations in children are especially well done. The book is exceedingly well written and contains numerous photographs.

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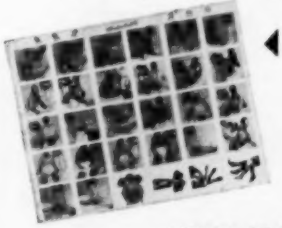

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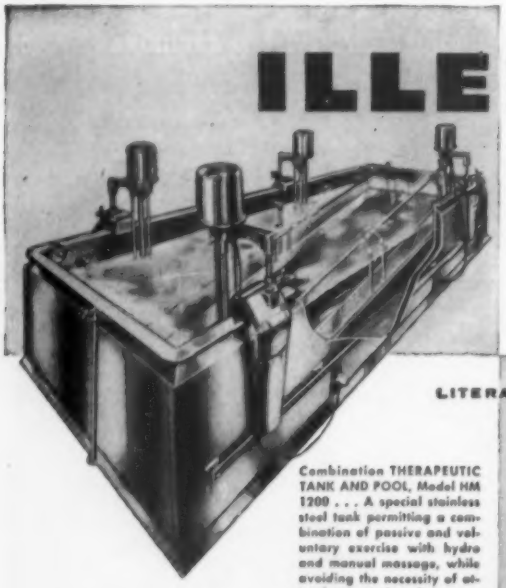

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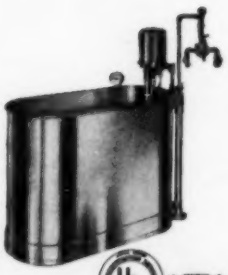

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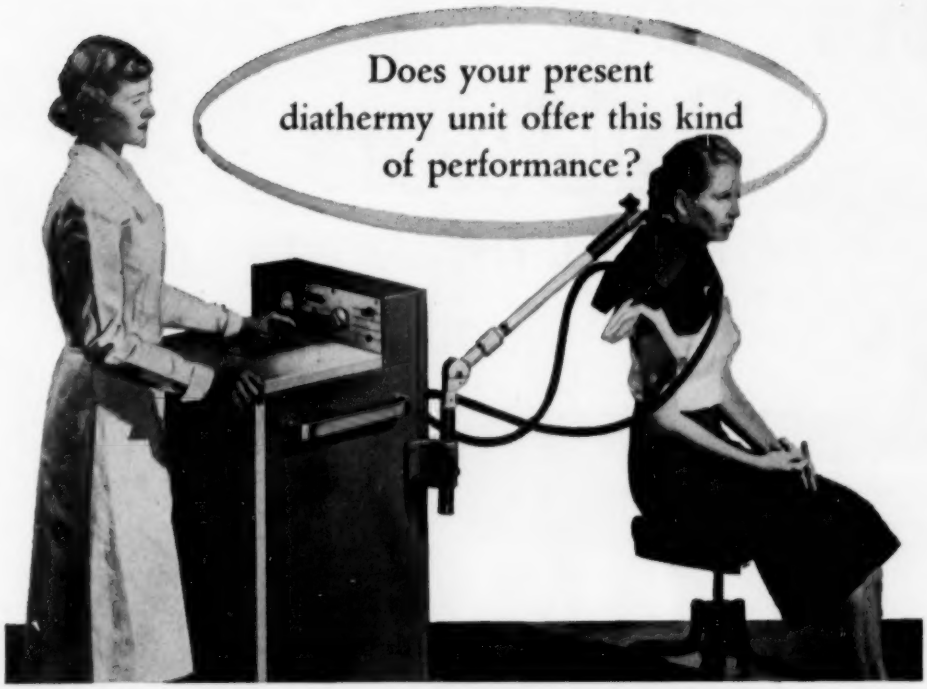

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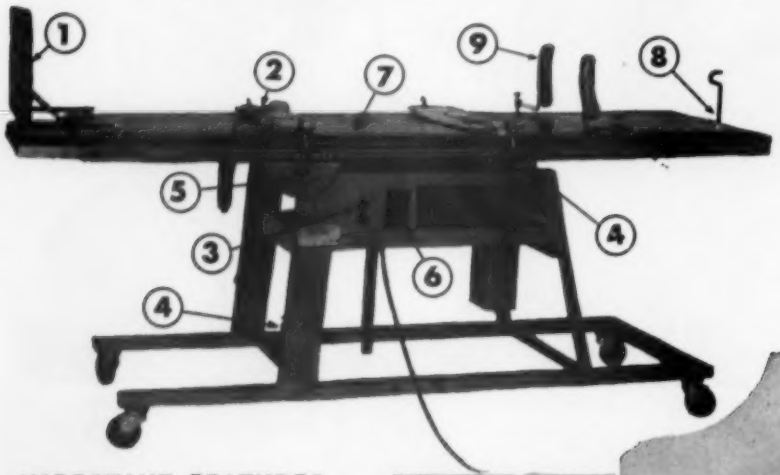

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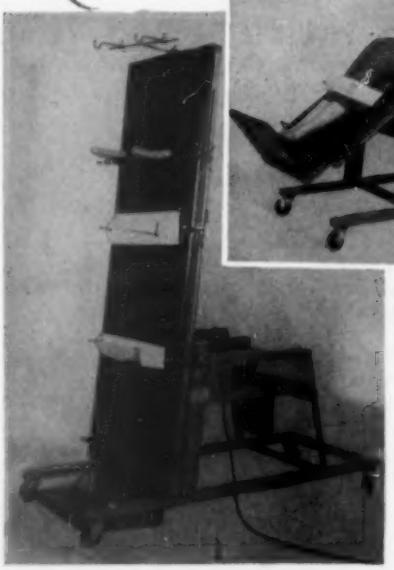

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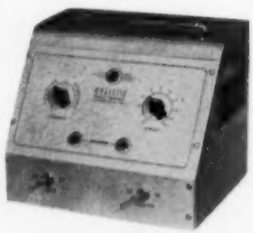

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Entrance Dates: First Monday in January, April and October.

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Course II — Three months duration with course I prerequisite. Emphasis on care of severe chronic physical handicaps with intensive training in resumption of functional activity and use of adaptive apparatus.

In-Service Training Program — Fifteen months duration at salary of $225 per month plus full maintenance. This program includes training in courses I and II.

Tuition: None. Maintenance is $100 per month. For scholarship to cover transportation and maintenance for courses I and II, contact National Foundation for Infantile Paralysis, Inc., 120 Broadway, New York 5, New York. (Scholarships require two years of experience).

For further information contact:

ROBERT L. BENNETT, M.D.
Medical Director
Georgia Warm Springs Foundation
WARM SPRINGS, GEORGIA

OPPORTUNITIES AVAILABLE

WANTED—Physiatrist, direct department, new hospital, affiliated medical school; East. For further information, please write Burneice Larson, Director, Medical Bureau, Palmolive Building, Chicago.

WANTED: (a) Senior physical therapist; voluntary general hospital, 600 beds; teaching affiliation; large city, medical center; Pacific Northwest. (b) Chief; new physical therapy department, 400-bed hospital; college town, East. (c) Physical therapist experienced in handling cerebral palsied children; new treatment center affiliated with crippled children's hospital; university town, Southwest. (d) To take charge new department, small general hospital; Michigan. (e) Two physical therapists interested in living in California; voluntary general hospital, 400 beds; department directed by physiatrist; expansion program. (f) Association with two American board surgeons; Midsouth. (g) Chief therapist; preferably man interested in both administrative and practice; duties include teaching; new 400-bed hospital; university medical center, South; outstanding opportunity. (h) Therapist, man or woman to take charge of departments, two crippled children's clinics; 4 days each month would be expected to travel to do followup work in surrounding counties; West. (i) Chief occupational therapist qualified to organize and direct the department; medical center, Midsouth. (j) Staff occupational therapist; 400-bed hospital; hour's drive from New York City.

For further information regarding these opportunities, please write Burneice Larsen, Medical Bureau, Palmolive Building, Chicago.

—WANTED—

Registered Physical Therapist for outpatient department large clinic in Southwest. Good salary, vacation with pay, 5½ day week. Apply Dr. L. M. Overton, Lovelace Clinic, 4800 Gibson Blvd., S.E., Albuquerque, New Mexico.

INSTRUCTION SEMINAR

in conjunction with the

33rd Annual Scientific and Clinical Session

American Congress of Physical Medicine and Rehabilitation

HOTEL STATLER — Aug. 28-Sept. 2, 1955 — DETROIT

PERIPHERAL VASCULAR AND PERIPHERAL NERVE DISEASE

Monday, August 29

9:00 - 9:50 A.M. PATHOLOGY OF PERIPHERAL BLOOD VESSELS. **Sidney Kobernick, M.D.**, Detroit.

10:00 - 10:50 A.M. TREATMENT of PERIPHERAL VASCULAR DISEASE. **Karl Harpuder, M.D.**, Bronx, N.Y.

11:00 - 11:50 A.M. NEUROANATOMY OF THE EXTREMITIES. **George C. Rinker, M.D.**, Ann Arbor, Mich.

2:00 - 2:50 P.M. VALUE AND LIMITATIONS OF ELECTRICAL STIMULATION IN PERIPHERAL NERVE LESIONS. **Jerome Gersten, M.D.**, Denver.

3:00 - 3:50 P.M. MUSCLE ACTION POTENTIALS: THEIR CAUSE AND MEASUREMENT. **Edward H. Lambert, M.D.**, Rochester, Minn.

4:00 - 4:50 P.M. ELECTRODIAGNOSTIC METHODS IN PERIPHERAL NERVE LESIONS. **H. D. Bouman, M.D.**, Madison, Wis.

Tuesday, August 30

8:00 - 8:50 A.M. PHYSICS AND PHYSIOLOGICAL EFFECTS OF ULTRASOUND WITH EMPHASIS ON ITS EFFECT ON PERIPHERAL MUSCLES AND NERVES. **Justus F. Lehmann, M.D.**, Rochester, Minn.

9:00 - 9:50 A.M. NERVE REPAIR AFTER INJURY. **E. S. Gurdjian, M.D.**, Detroit.

PSYCHIATRIC AND VOCATIONAL TOPICS OF REHABILITATION

Monday, August 29

9:00 - 9:50 A.M. PERSONALITY STRUCTURE AND ITS EFFECT ON REACTION TO CRIPPLING ILLNESS. **John C. Nemiah, M.D.**, Boston.

10:00 - 10:50 A.M. HELPFUL AND HARMFUL ATTITUDES OF THERAPISTS AND PHYSICIANS TOWARD PATIENTS. **Jack Meislin, M.D.**, Montrose, N.Y.

11:00 - 11:50 A.M. PSYCHIATRIC ASPECTS OF CHRONIC BRAIN DISORDERS AND THEIR IMPORTANCE IN PHYSICAL MEDICINE AND REHABILITATION. **M. M. Frohlich, M.D.**, Ann Arbor, Mich.

2:00 - 2:50 P.M. PSYCHOTHERAPEUTIC EFFECTS OF EXERCISE AND WORK THERAPY. **Ivan C. Berlien, M.D.**, Detroit.

3:00 - 3:50 P.M. VOCATIONAL APTITUDE TESTING. **Kenneth W. Hamilton**, Columbus, Ohio.

4:00 - 4:50 P.M. PRINCIPLES OF VOCATIONAL TRAINING FOR THE HANDICAPPED. **Kenneth W. Hamilton**, Columbus, Ohio.

Tuesday, August 30

8:00 - 8:50 A.M. THE SHELTERED WORKSHOP AS A STAGE IN REHABILITATION. **Emil Trapani**, New York City.

9:00 - 9:50 A.M. INDUSTRIAL PLACEMENT OF THE PHYSICALLY HANDICAPPED. **William A. Irwin, M.D.**, Dearborn, Mich.

Physicians as well as physical therapists who are registered with the American Registry of Physical Therapists will be permitted to register for these courses. Members in good standing of the American Occupational Therapy Association are also eligible to enroll in the seminar. The schedule of the seminar as arranged, will permit attendance at both the course and scientific sessions.

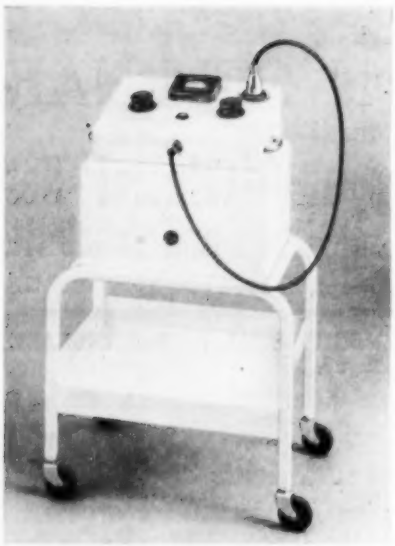
Each registrant for the course is allowed the choice of one lecture during a period. The charge for the complete schedule of eight lectures is $15.00. Fewer than eight lectures may be scheduled at $2.00 each. The right is reserved to reject any application if the Committee finds it desirable to do so. Registration for specific courses cannot be guaranteed when quotas are filled.

The Committee on Advances in Education is grateful to the Committee on Correlation of Physical Medicine and Psychiatry for its assistance in helping plan the Instruction Seminar.

For full information and application form address

AMERICAN CONGRESS OF PHYSICAL MEDICINE AND REHABILITATION

30 North Michigan Avenue Chicago 2, Illinois



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